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HAND PLUCKING TEA IN JAPAN.

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TEA IN JAPAN

Acknowledgment

When Dr. Fumio Maruo of the Government Tea Experimental Station, Shizuoka, visited Tocklai in 1921 he invited me to Japan in order that I might see something of the tea industry in his country. Unfortunately Dr. Maruo died in Formosa a year later. When the news reached me I had made all arrangements for the voyage and was somewhat at a loss as to the best way to set about seeing what I knew to be a village industry, in a strange land of whose language and customs I was entirely ignorant. However, when I explained my difficulty to the Japanese Consul in Calcutta he furnished me with letters of introduction to the Director of the Kyoto Experimental Station and to Mr. T. Miyachi, Director of the Tea Experimental Station at Kanaya.

At Kyoto, where I stayed several days, Mr. K. Hisada and Mr. M. Nakashima, of the Experimental Station there, took great pains to show me all they could of the tea in the Uji district and to supply me with scientific data.

At Kanaya, a village off the beaten track, I was most hospitably received by Mr. T. Miyachi, who acted as my host during my stay in the district. He took me to many gardens and made sure that I should see most things connected with the first season's plucking and manufacture. The records and scientific findings of the Experimental Station were placed at my disposal and all the members of the staff did their utmost to help me.

At Makinohara I met Mr. K. Maruo, brother of the late Dr. Fumio Maruo, who is in charge of the Shizuoka Experimental Station. Here again, every kindness was shown me and the greatest possible help given.

Mr. T. Miyachi and members of his staff accompanied me to the city of Shizuoka and took me round the re-firing factories, both Japanese and European. Mr. T. Miyachi also provided me

with introductions to the Central Tea Association in Tokyo, where I was able to get interesting information with regard to the commercial side of the industry, and to Dr. Shivata, of Tokyo University, with whom I had an interesting discussion on the chemical aspect of the quality of green tea.

In short, I received nothing but kindness and help from the start to the finish of my tour and I take this opportunity of expressing my sincerest thanks.

C. R. HARLER.

Tocklai, Cinnamara,
Assam, 1923.

ILLUSTRATIONS.

1. Tea Plucking in Japan.
2. A Tea Garden at Kanaya, Shizuoka.
3. Hand-rolling Tea.
4. The Tea Factory at Kanaya Experimental Station.

TEA IN JAPAN

BY

C. R. HARLER, B.SC., F.I.C.

INTRODUCTION

Japan proper consists of four large islands—Hakkaido, Honshiu, Shikoko and Kiushiu—and numberless small ones, stretching from about lat. 46°N to lat. 31°N. The total area is 151,000 sq. miles and the population is estimated at 50 millions.

The country is for the most part mountainous, the only considerable plain being that about Tokyo. There are slight earthquake tremors daily, perceptible only by delicate instruments, several severe shocks yearly, and at intervals of from forty to fifty years a terrible catastrophe, causing widespread destruction. Devastating tidal waves produced by submarine earthquakes are frequent. All these seismic movements are largely traced to the fact that the shores on the Pacific side are slowly rising and those bordering on the Sea of Japan are sinking. A great geological fault is supposed to run along the west of the country.

According to a legend, now firmly established, Lake Biwa, near Uji, owes its existence to a great earthquake in the year 286 B.C., whilst Fujiyama, the sacred mountain of Japan, rose out of the plain of Suruga at the same moment.

Although within recent years Japan has made great advancement as a manufacturing country and has, in a stride, taken first place amongst the industrial nations of the East, her population is still essentially an agricultural one and sixty per cent. of the people are agriculturists. As husbandmen the Japanese rank high. They have that instinctive knowledge of crops and the soil which goes with a race which has been farming for forty centuries. This knowledge is now associated with the latest scientific discoveries and experience gained at the agricultural stations situated in each prefecture.

The chief agricultural soil consists of Tertiary and alluvial deposits, not rich, but forming an easily worked, friable loam. The Quarternary alluvial, argillaceous soils are more fertile, and, lying low, are well suited to irrigation. Much of the best rice land belongs to this class and rice is the chief crop.

Tea is mainly grown in the Shizuoka prefecture and the city of that name is the business centre of the industry. The second district is that of Kyoto with neighbouring prefectures of Shiga, Miye and Nara. It is at Uji in the Kyoto prefecture that the famous Gyo Kuro tea, reputed to be the finest in the world, is grown. The only other tea district of any importance is in the Kumamato prefecture on the island of Kiushiu. The following table shows the amount of tea produced by the leading districts in 1918. Kyoto is the second district in point of view of the value of the tea produced, although Miye is second in quantity.

Shizuoka	... ...	36,752,000 lbs.
Kyoto	... ...	3,486,000 ,,
Shiga	... ...	2,468,000 ,,
Miye	... ...	6,418,000 ,,
Nara	... ...	3,559,000 ,,
Kumamato	... ...	3,145,000 ,,

Tea farming in Japan is a subsidiary industry, for the cultivator prefers to plant out his flat land and his best areas with other crops. The result is that tea is relegated to areas which are often remote from the railway and deficient in means of transport. These factors all tend to handicap tea cultivation at the expense of other crops.

Tea and mulberry cultivation were at one time twin industries, but whilst the latter has advanced, the tea industry has been at a standstill. From 1915 to 1919 the area under tea remained steady at about 119,660 acres, which was owned by 1,122,164 farmers. This is indicative of the nature of the Japanese industry and offers a striking contrast to the enormous size of tea gardens in India. A common size for a tea garden is a quarter of an acre, but every farmer does not have his own factory.

Most of the tea made in Japan is green tea. The finest tea is known as Gyo Kuro (Pearl dew), and is manufactured from specially shaded bushes in the gardens round Uji in the Kyoto district. The second grade is known as Sencha, and the third grade, which often includes the top prunings of the bushes, is known as Bancha. A trifling quantity of black tea is made. In 1919 the output was as follows :—

Gyo Kuro (Green tea)	...	627,000 lbs.
Sencha („)	...	59,592,600 „
Bancha („)	...	21,336,800 „
Black tea ...	...	419,700 „
Total	...	81,976,100 „

Of the tea made about 45% is kept for home consumption and the balance is exported, chiefly to America and Canada.

Twenty-five years ago all the tea was exported from Kobe and Yokohama. Then the port of Shimizu, a few miles from Shizuoka city, developed and now it is the premier tea port for the country. Kobe has ceased to export tea and Yokohama exports only about two million lbs. annually. The port of Hokkaido, conveniently situated for the Kyoto district, exports about the same quantity as Yokohama.

The amount of tea exported annually, from a year or two prior to the War up to the present year, is instructive.

Year.	Total lbs.
1912	35,507,289
1913	29,540,945
1914	33,747,990
1915	39,311,059
1916	41,460,431
1917	42,345,974
1918	41,400,514
1919	27,799,728
1920	22,816,015
1921	16,552,971
1922	26,131,250

The slump in 1921 is attributed to the stocks accumulated during the war years. This offers a distinct parallel to the slump experienced in the Indian tea industry about a year earlier.

The Climate of Japan.

In order to appreciate tea cultivation and manufacture in Japan and to compare and contrast the processes and methods with those employed in India, some knowledge of the climate is necessary.

The outstanding factor influencing the climate of Asia is the air flow to and from the Central Asiatic Plateau which movement is generally spoken of as the Monsoon. The Central Plateau, known as the Gobi desert, experiences a continental climate of extremes. In the summer months Gobi becomes much hotter than the surrounding countries and the general air flow is from the sea to the Plateau. The air moves across India from the south-west depositing rain on the western coast and along the Himalayas. In Burma the wind movement has a more southerly direction and in China the general summer movement is from the East. The Malay Peninsula and the East Indies are outside the direct influence of the Monsoon and lie within the belt known as the Doldrums where a steady hot, moist climate is experienced.

In the winter months, the Gobi desert is much colder than the surrounding countries and the air movement is from the land towards sea. This brings the cold, dry season to India and China.

Japan is only slightly influenced by monsoon conditions, for it is separated from the Continent of Asia by the Sea of Japan which modifies the cold winter winds blowing from the Gobi desert. The monsoon change means little more than a change in wind direction. In the cold weather the winds blowing from the Continent of Asia deposit rain on the western side of Japan. In the warm weather the breezes blow more from the Pacific and the eastern shore than gets the first and greater share of the rain.

All the tea is grown on the eastern or warm side of Japan and the heart of the tea districts is Kanaya in the Shizuoka prefecture. Much of the tea is planted on areas exposed to the full force

of the elements where other crops would fail or fare only moderately well. The other important district centres round Nara and Kyoto and includes the Uji gardens. This area is much more protected than the Shizuoka district, for it is on the average thirty miles from the sea and on this account is somewhat warmer in summer and slightly colder in winter.

Apart from the topographical situation of Kanaya, which greatly influences its climate, it is interesting to observe that the latitude of the district is about 35°N. This is roughly the same latitude as that of Southern Spain and about 10° further north than the tea areas of North East India. It must be observed however that a direct comparision between latitude and climate is not possible so far as India is concerned, for the proximity of the North East Indian tea districts to the Central Asiatic Plateau outbalances all other climatic factors.

Kanaya is situated on a bold, almost treeless headland between the Oi and Tenryu Rivers, overlooking on either side, the Pacific Ocean. In the spring, with a stormy wind lashing the countryside with sleet the climate seems anything but suitable to tea. During such weather, the booming of the ocean upon the rocky headland is distinctly heard far inland.

In fine weather the scene from Kanaya is one of the supreme beauty and grandeur. The promontory itself is one mass of brilliant green, green as only the tea bush can be. Away in the valley of the Oi is the beautiful patchwork of colour associated with a diversity of crops, and on the farther bank of the river the land rises again and the slopes are clad with tea which finally gives way to pine forests. Overlooking the whole scene is sacred Fujiyama, a perfect, snow-clad cone.

The scenery in the Kyoto district is much less wild than that round Kanaya. Uji is prettily situated on the Ujigawa which circuitously finds its way from Lake Biwa to the sea at Osaka.

Below are given the monthly average maximum and minimum temperatures and rainfall of Kyoto and Kanaya together with the corresponding figures of Tocklai, as representing the plains climate

of the tea districts of North East India, and Darjeeling, as representing the hill climate.

Month.	Kyoto.			Kanaya.		
	Max.	Min.	Rainfall.	Max.	Min.	Rainfall.
	°F	°F		°F	°F	
January ...	47·4	34·9	2·14 ins.	47·5	33·9	2·83 ins.
February ...	48·7	34·2	2·62 ,,	51·4	34·5	5·53 ,,
March ...	52·2	33·6	4·57 ,,	55·7	37·6	7·45 ,,
April ...	66·8	42·1	4·38 ,,	64·9	48·5	10·95 ,,
May ...	74·0	50·0	3·64 ,,	71·2	54·2	9·02 ,,
June ...	80·9	62·4	9·45 ,,	75·2	61·7	10·99 ,,
July ...	89·1	70·9	5·34 ,,	82·1	69·7	8·17 ,,
August ...	88·9	70·5	5·59 ,,	84·6	70·7	12·29 ,,
September ...	73·1	64·6	8·91 ,,	79·3	65·5	15·23 ,,
October ...	72·7	52·7	6·16 ,,	71·0	56·1	7·80 ,,
November ...	61·8	41·6	3·73 ,,	62·5	47·6	7·14 ,,
December ...	51·6	32.6	2·73 ,,	52·7	35·6	3·01 ,,
		Total	59·26 ins.		Total	100·41 ins.

Month.	Tocklai.			Darjeeling.		
	Max.	Min.	Rainfall.	Max.	Min.	Rainfall.
	°F	°F		°F	°F	
January ...	70·2	48·5	0·68 ins.	46·8	34·8	0·76 ins.
February ...	72·6	53·3	1·19 ,,	47·9	35·6	1·08 ,,
March ...	79·1	60·0	4·22 ,,	56·5	42·3	2·01 ,,
April ...	82·6	65·6	8·88 ,,	62·2	48·9	4·08 ,,
May ...	84·9	71·6	8·83 ,,	63·8	52·6	7·83 ,,
June ...	89·7	76·6	13·25 ,,	65·2	56·2	24·19 ,,
July ...	90·0	78·0	13·23 ,,	66·0	57·7	31·74 ,,
August ...	89·3	77·8	13·67 ,,	65·5	57·2	25·98 ,,
September ...	88·0	75·6	9·95 ,,	64·1	55·5	18·34 ,,
October ...	84·8	70·8	4·42 ,,	60·5	49·8	5·35 ,,
November ...	78·1	59·8	0·59 ,,	54·2	42·4	0·24 ,,
December ...	71·0	50·4	0·57 ,,	48·7	36·6	0·20 ,,
		Total	79·48 ins.		Total	121·80 ins.

It will be seen at a glance that there is no dry season in Japan, the summer months are merely wetter than the winter ones. At Kyoto the temperature range is generally greater than at Kanaya and this is to be expected for Kyoto is about thirty miles from the sea and escapes its modifying influence. At Kyoto also the rainfall is many inches less than at Kanaya. The higher temperatures at Kyoto are believed to account partly for the better quality of the tea from that district.

The temperatures in Japan are lower than those recorded in the plains of Assam but are much higher in the summer than those at Darjeeling. It must be borne in mind however that many of the Darjeeling gardens are in valleys which warm up considerably during the day and thus show much higher maxima than the town of Darjeeling at which place the observations recorded in the above table were made.

May and June are the chief plucking periods in Japan and during these months the maximum temperature at Kanaya is about 73°F and the minimum about 16°F lower. This range ensures that the atmosphere shall not become very humid judging by Assam standards because there will be a considerable nightly deposition of moisture as dew which keeps the atmosphere moderately dry. In spite of this, however, the bushes flush vigorously in a manner seldom seen in India even during the most favourable, hot, steamy periods of August and September. The vigorous flushing is no doubt due to heavy doses of nitrogenous manures.

The effect of the low temperatures on tea manufactured in Japan is of great interest. Thus leaf plucked in the evening may be stored overnight before steaming. Of course where the best green tea is made, steaming is always carried out as soon as possible after plucking. In India when green tea is made the climate is such that an interval of several hours between plucking and steaming would ruin the quality of the tea.

Black tea is only made in very small quantities in Japan and then it is not a success. This failure may be attributed to many causes, *e.g.*, the lack of suitable yeasts or bacteria, but it hardly seems attributable to an unsuitable climate for the temperatures at Kanaya are about midway between those of Darjeeling and Assam. In any case black tea is not a success when made in Japan and it seems unlikely that this country will ever be a rival to India so far as the tea industry is concerned.

All the tea bushes in Japan are of the China type. It is interesting to remark that Assam indigeneous tea seeds taken from Tocklai by Dr. Fumio Maruo and planted at Makinohara, near

Kanaya, in 1920 have made very little headway owing to the rigorous climate and inability to withstand the frosts. Most of the plants died and the few survivors were but six or eight inches high after two year's growth. In the Darjeeling district, China bushes are usually planted because they are considered to give the best quality tea. Assam bushes are sometimes planted and do fairly well.

Sunshine in Japan is believed to increase the strength of the tea but to make the taste bitter and the colour darker. In India it has been noticed that sunshine increases the tannin content of the tea leaf.

The table shows the average daily hours of sunshine at Kyoto and Kanaya.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Kyoto	4·1	4·5	5·7	7·0	7·4	5·7	7·0	7·3	4·5	5·9	5·5	5·2
Kanaya	6·0	4·9	5·9	6·1	5·1	2·7	4·2	5·7	3·6	4·6	4·8	5·7

June and September in the Shizuoka district are periods giving poor quality teas, not because of lack of sunshine, which would make for quality in green tea, but because of heavy rainfall. Experience shows that leaf which is plucked wet does not make good tea, but this fact has not yet been scientifically explained.

The Japanese Tea Association.

The Central Tea Association, under Government guidance, was formed in Tokio in 1883 and since then Prefectural and District Associations have been formed. There are about twenty of the latter Associations.

The object of the Central Association is to prevent the sale of inferior tea, to unify packing, etc., and to advertise Japanese tea abroad by opening tea shops and by newspaper demonstrations.

At the principal stations and ports, tea is examined for stalk, dust and water content. If tea has a smoky flavour it is not allowed to be exported. In the District offices tea samples are

examined for "facing." "Tea faced" with small quantities of indigo have an improved appearance and are said to keep well. As small a quantity of indigo as 1 to 5 million parts of tea is sufficient for practical purposes. In order to test for "facing" the tea is sieved through a 100-mesh sieve and the powder so obtained is rubbed on paper which clearly shows a blue mark if an excessive amount of colouring has been used. If only a small quantity of colouring matter is detected, the tea may be washed with water and again put up for examination. If however a large quantity is present the tea is destroyed.

The Tea Association derives its income from various sources, the chief of which is the *kahyo* or ticket which must be affixed to boxes of tea. Each *kahyo* costs 20 sen (*5d.*) and one must be stuck on all boxes of tea weighing under 120 lbs. when they are transported from one district to another or exported. If a box is above this weight, two tickets are needed.

Each farmer, manufacturer and merchant is bound to belong to the Association and to pay a certain sum towards its upkeep. The income of the Central Association is about Yen 90,000 (£9,000).

The District branches deal with local affairs. Farmers and manufacturers are trained, tea shows are arranged and machinary inspected.

In the city of Shizuoka, where the tea for export is re-fired and packed, there is also an Association of Tea Firers.

At Kanaya, about twenty miles from Shizuoka, is situated the Government Tea Experimental Station which has been established four years. The station has good laboratories and a first class factory, both hand and machine. There are fifteen acres of tea for experimental purposes. The staff consists of three chemists, two agriculturists, four technologists, an engineer and an entomologist. The yearly expenditure is about Yen 42,000 (£4,200).

In addition to the Government Station there is a much older station at Makinohara about two miles away which was first established privately by several members of the district and was transfered to the Shizuoka prefecture in 1909. The area of the station

is about eleven acres, of which seven acres are under tea. It is much smaller than the Kanaya establishment, there being only three scientists. The yearly expenditure is about Yen 16,000 (£1,600).

At Makinohara tea experts are trained and are then sent into the districts. About 40 or 50 men are also trained each year in the autumn and winter both by lectures and practically. Experts lecture and demonstrate in the districts. This station is for demonstration and education rather than for research.

In the Kyoto district the scientific study of tea is carried on by the Agricultural Department of the prefecture and does not receive any special attention but takes its place among the study of other crops.

The Tea Soils.

As was mentioned above, tea in Japan is not planted on the best land, but for preference on areas where rice and other crops cannot be grown. Except round about Uji, tea is usually cultivated on steep slopes and bare, wind swept plateaux. Rows of tea bushes are grown on the banks dividing rice fields, small patches are planted in orchards, amongst mulberry bushes, and in fact in any odd spot where there is room. Round Uji considerable areas of fairly low lying land are given over to tea cultivation.

The effect of the type of soil on the appearance of leaf and quality of the tea is believed to be great. Red clay soils are said to give brownish yellow leaves, whilst the humus in the soil produces dark green leaves. Sandy soils are said to produce light green leaves. Whilst a dark coloured leaf is preferred it is thought that flavour is given by clay soils. For export also the teas grown on clay soils are thought to be good.

The shape of the leaf is said to be influenced by the soil. Thus a red soil gives a long narrow leaf which twists well.

In such a large area as the Shizuoka prefecture there is naturally every type of soil and each district produces tea whose qualities are linked up with those of the soil. The Kanaya district, in which red soil predominates, gives middle quality strong tea with poor

TEA GARDEN AT KANAYA, JAPAN.

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colour. The Abe district, near Shizuoka city, where the soil is loamy, produces good quality tea. The district round about the town of Fiji from which the land slopes to the volcanic Fujiyama, produces thin, weak tea, good neither in taste nor smell but good in colour. This is at first surprising since the soil here is black from volcanic ash and humus, but the greenness, so sought after, comes not from virgin soil but from manure and also from shading.

The soil on mountain slopes along rivers is supposed to be good for tea. Kawane, a small district in the Oi valley, produces the best tea in the Shizuoka prefecture.

It would be of great interest to compare the Japanese tea soils with those of North East India, but this cannot be done in a very satisfactory manner owing first of all to the scarcity of analyses of the Japanese soils and secondly to the different analytical methods employed.

Below is given the analysis made at Tocklai of a soil from the Uji district and the results are therefore directly comparable with those shown by Indian tea soils examined at Tocklai. The Uji soil is black but it compares well with the Dooars red soil which has more clay and is richer in total potash.

	Uji.	Red Bank, Dooars.
Moisture	5·9	7·3
Soluble in dilute acid	1·0	1·2
Gravel and Stones	nil	4
Coarse sand	14	12
Fine sand	16	6
Silt	11	17
Fine silt	21	14
Clay	18	28
Loss on ignition	12·9	9·8
Nitrogen	0·24	0·22
Total potash	0·23	0·85
„ phosphate	0·041	0·99
„ lime	0·089	0·11

Available potash	0·043	0·024
„ phosphate	0·0096	0·016
Humus (Grandeau)	6·18	4·3
Acidity (Hopkins)	667	1600

Like the Indian tea soils, most of the Japanese soils are acid. Daikuhara (Bull. Jap. Imp. Cent. Agr. Stn., 1914, 2, 1-40) describes them as acid mineral soils which only give a faint acid reaction but react acid when treated with neutral salts. Such salts depress the crop. The acidity of the North East Indian soils is of a similar type although crop depression with ordinary doses of neutral salts has only been suspected in a few cases.

Below are given partial analyses of six soils, two from the Kyoto area and four from the Shizuoka area. These were all the tea soil analyses available, for the research work in Japan appears to have tended towards the study of tea manufacture rather than in the direction of soil study.

	Kyoto District.		Shizuoka District.			
	Uji.	Kuge.	Kiosawa gravelly loam.	Shizuoka loam.	Karsahara sandy loam.	Makinohara humic loam.
Available phosphate ...	0·71	0·106	...	...	...	...
„ potash ...	0·010	0·010	0·02	0·008	0·010	0·006
„ lime ...	0·025	0·025	0·13	0·16	0·20	0·10
Humus	1·71	1·62	...	...	...	...
Acidity (Daikuhara) ...	57	48	acid	neutral	faintly acid	acid
Total nitrogen ...	...	...	0·44	0·25	0·17	0·51

As a comparision with the Indian tea soils there is little to go upon. The phosphates appear to be very high and the potash low, which characteristics are shown by the Uji soil first mentioned. The total nitrogen is high compared with the ordinary run of soils.

From the mere look of the tea soils they appear to be much richer than those of Assam where the soils are admittedly poor, but support tea on account of the climate. The depth of the Japanese soils is also a matter for remark for at two feet they appear to be still as rich as on the surface.

Cultivation.

The tea gardens are cultivated three or four times a year and more often in the Uji district. The soil is generally hoed in April, before the first plucking, to a depth of about five inches, again in June and again in September or October. Trenching to a depth of two feet accompanied by burial of the summer weeds is often carried out in the autumn. Failing this, a hoe, about ten inches deep, is put in at the fall.

Much use is made of mulching with straw or bamboo leaves. The latter type of mulch is preferred to rice straw which encourages insects. Another reason for the preference of bamboo is that tea usually grows on the hills far removed from the rice fields and labour is necessary for transporting the straw. The mulch is put down in the autumn and is kept down till it is buried the next autumn. The soil is thus kept moist and free from jungle, but if labour is available the mulch is removed for light cultivation and then put back. An acre of land may carry as much as 32,000 lbs. of leaves and straw as a mulch.

There are no drains in Japanese tea gardens and practically no real terracing as is understood in the Darjeeling district. Round about Shizuoka city there is a certain amount of rough terracing, but, generally, wash is arrested by means of hedge planting.

Manuring.

The traveller need only go into the country side of Japan for a few miles to realise that the chief manure used is night soil. Along the roadside are receptacles for its storage, and its transport and application all help to charge the atmosphere with its odour.

For all practical purposes the only manures used on tea gardens are those supplying nitrogen as their chief constituent. Round Uji a typical dose is :—

2,000 lbs. rape oil cake (4·5% N.) per acre.
20,000 „ faeces (0·7% N.) per acre.

This makes a total application of 230 lbs. nitrogen per acre together with a considerable quantity of phosphates and potash.

The true significance of this application will be appreciated when it is remembered that 30 lbs. nitrogen per acre added as a quick acting manure is considered a normal dose in Indian tea gardens and that 5 tons (11,200 lbs.) of cattle manure containing 0·5% nitrogen, making a total of about 56 lbs. nitrogen, is considered a fair dose of a slow acting manure.

The Japanese tea farmer values faeces more highly than any other manure but the cost of application has risen so much with the recent rise in wages that he is often forced to substitute oil cake. Soya cake is cheap and popular but in the Uji district rape cake, which is dearer, is still used according to custom.

The manure is added two or three times a year, preferably at cultivation time. It is either put in a trench round the bush or put into the centre of the bush.

Quick acting manures, *e.g.*, ammonium sulphate, sodium nitrate, are sometimes used and are added four or five times in the spring. Farmers however do not favour quick manures for the quality of the tea depreciates with their use. Oil cake is sometimes made into a quick manure by soaking in water and it is then added in the spring. The more popular method is to add slow acting manures in the autumn.

Lime is not used, for farmers say that with its use the quality of the tea, especially of Gyo Kuro and powder, becomes poor.

There is an idea that high bushes need much manure and that low bushes are more economical because they need little manure. On the other hand it is believed that high bushes give the best quality tea.

At the Shizuoka Experimental Station, experiments have been carried out to find the value of various manures. So far, phosphatic manures up to 160 lbs. P_2O_5 per acre have not been found to increase the crop. Nitrogenous manures always get a response in crop return.

Japanese tea farmers are prejudiced against green crops as manures on the grounds that quality will be lost if they are employed. Work at Kanaya has however shown that green

manuring makes for quality. Vetch, Soya bean and Seradella (*Ornithopus Sativus*, Brot.) have been used. Seradella, sown in September and cut in June, grows to a height of two feet and gives a crop of about six tons per acre. Soya bean, sown in April and cut in August, grows to a height of four to five feet and gives a crop of over two tons per acre. Vetch, resembling Seradella, grows to a height of five feet but climbs over over the tea. The crop is about six tons per acre.

Red Clover is sometimes cultivated as a green crop and Astragalus Sinicus is grown in the rice fields in the winter months and transported to the tea gardens.

The Tea Plant and Style of Planting.

At one time the idea that good tea was made solely in the factory prevailed amongst tea farmers, but now the influence of the type of plant is recognised. In most rows of tea, in fact in almost every clump of bushes, several species of tea may be recognised. Although all the tea plants are of the type loosely termed China, many botanical varieties of this one type exist. It is hoped to propagate a pure strain of plant by means of cuttings. The choice of a strain will be influenced by the opinion that medium sized leaves give the best tea.

As was previously mentioned, Assam indigenous plants do not thrive in Japan. Of the seeds taken there from Assam, about 65 per cent. germinated, but the young plants practically all died in the winter in spite of the fact that they were protected from the cold with straw matting.

The Japanese tea farmer never puts out nurseries. The seeds are planted, almost touching, in circle of about eighteen inches diameter and a clump the shape of a hive thus grows up. The distance between each clump is two to three feet so that eventually the bushes merge into each other and an undulating row of tea, resembling a box hedge, is obtained. The distance between the centres of the rows is five or six feet. This method of planting is common in the Uji district.

In the Shizuoka district, line planting, with a gap of about six feet between the lines, is favoured. The seeds are planted, with no particular care, almost touching each other. Row planting is particularly suited to slope areas for the loss of surface soil by washing is thus practically obviated.

Tea is sometimes propagated by means of cuttings. At Kanaya much success has been obtained by the following method. In the month of June, a shoot about six inches in length is cut and put into the ground after most of the leaves and the buds have been taken off in order to prevent too rapid growth. The shoot is transplanted after two years.

Another method of propagation is "layering." A lateral branch is taken, the bark scraped for an inch or so below an eye, and the branch is then pegged down so that this eye is buried. When rooted it is cut and planted carrot fashion. The branch may be manured with oil cake or fish manure and protected with rice straw.

Plucking and Pruning.

In Japan, tea is plucked three and sometimes four times a year, the shoot consisting of three to five leaves. The first plucking is made in May and from this crop the best tea results. The second plucking is made about mid June and good drinking tea is then made. In the Uji district the first tea, which is from shaded bushes, is called Gyo Kuro. A description of this shading is given later on. The second tea, called Sencha, is a good drinking tea. In the Shizuoka district the bushes are seldom shaded and both first and second teas are called Sencha. The third plucking is made in July or August and the crop, which is a mixture of new and old leaves, is made into a poor quality tea called Bancha.

Gyo Kuro may sell at a price varying from Yen 3 to 13 (6*s*. to 26*s*.) a pound. This tea has a sweet taste and is best made by using boiled water which has somewhat cooled.

The price of Sencha varies from one Yen to Yen 1·50 (2*s*. to 3*s*.) a pound. The Sencha of the first plucking is the best. The second plucking is made in the rainy month of June which

accounts for the poor quality of the tea. Sencha is best made with boiling water.

The price of Bancha is about 30 sen (7½*d.*) a pound and although August teas are better than those of June the fact that ordinary Bancha contains many old leaves makes it inferior to Sencha. Generally, too, its manufacture differs from that of the first two pluckings, for the leaf is merely steamed and dried without rolling.

The plucking periods of the various grades and the names of the pluckings are given below :—

May	... Ichiban-cha	first season's plucking lasts	40-50	days.
June	... Niban-cha	second „ „ ... „	20-30	„
August	Samban-cha	third „ „ ... „	10-15	„
Sept. & Oct.	Yoban-cha	fourth „ „ ... „	10	„

Although the plucking period extends over many days, each bush is only plucked once in each period.

Yoban-cha is poor tea, thin in liquor, taste and flavour but with a fair colour. This grade of tea is favoured by some drinkers. The fourth plucking is not always made and it has been shown at Makinohara that three pluckings are more economical than four, for over a period of years the crop from three pluckings is greater than that from four.

Only the light green leaf is plucked if good tea is being made, for the dark green leaf contains anthocyan which gives the bitter taste to poor quality teas.

The crop, judged by Indian standards, is huge. In the Shizuoka district as much as 16,000 lbs. green leaf which makes up into somewhat less than 4,000 lbs. (50 maunds) tea per acre has been obtained, but this is exceptional. In the open fields of the Uji district (*i.e.* without shading) as much as 2,800 lbs. (35 maunds) tea an acre may be expected. With shading, somewhat higher yields are obtained. These values are much above the average and are taken from gardens which grow for export and not merely for home consumption.

Hand plucking is becoming a thing of the past and a kind of scissors or light shears are now employed for cutting the leaf. Farmers round Uji however still try to pluck their first teas by hand. With hand plucking 25 to 30 lbs. leaf per day is a fair task, but with scissors from 200 to 250 lbs. may be obtained by a woman. A maximum of 432 lbs. has been plucked and the average task for a man is 300 lbs.

The farmer was naturally opposed to scissors plucking at first but the steady rise in wages has forced him to adopt this method. Forty years ago the daily wage of a plucking woman was 8 to 10 sen (2*d.* to 2½*d.*). Before the war it had risen to 50 sen (1*s.*) a day and at present it is from 80 sen to Yen 1·50 (1/7½ to 3*s.*) a day. Plucking scissors are not generally used for ichiban-cha (first season's tea) but their use even here is increasing.

The blades of the plucking scissors are about eight inches long. One blade is fitted with a scoop and the other blade with a long, open-ended bag, the mouth of which is kept open by a thick wire loop fixed to the blade. The end of the bag is held in the right hand with the right handle of the scissors and when the bag is filled it is emptied into a basket.

The ease of plucking by this method will be appreciated when it is understood that the Japanese tea bush resembles a box hedge and the flush is one continuous, thick, even spread of leaf. Fine leaf, containing little stalk, is obtained by plucking scissors.

Attempts to use the plucking scissors in Assam have not met with any success as yet for the amount of leaf per unit area in North East India is very small and would only average about ½ oz. of leaf from each bush per plucking, reckoning on a 10 maunds *pucca* tea crop on a 3,000 bush per acre garden, with 30 pluckings in the season. By changing pruning methods and plucking periods however it is possible that scissors plucking may become practicable in India. In Japan it is found that real success is only obtained after the bushes have been plucked into shape by scissors for three years.

A system of pruning such as is followed in North East India is unknown in Japan. The bushes may begin to yield leaf after

four years growth and from that time if scissors plucking is employed, no pruning is necessary. In August the plucking with scissors is made to a depth of about six inches and is similar to "scutching" or "skiffing" as performed in Assam, and these prunings, which include young and old leaves, are made into Bancha, the third quality tea.

The appearance of the wood of the tea bushes is spindly and it is covered with mosses and lichens. In fact each "bush" consists of a clump of gnarled, single stem plants of various heights which give a continuous dome shaped plucking area from the crown of the bush down to the soil. Many of the bushes are said to be a hundred years old.

When the bush appears to be exhausted it is cut low down. After this the leaves get bigger and the bush improves for four or five years but then it again deteriorates. Heavy pruning is only resorted to in extreme cases for a high bush is said to give good quality tea.

In the Shizuoka district the bushes are cut back to about two feet once in every five or ten years but, in the Kyoto district, the quality gardens only cut back once in thirty or forty years.

Experiments have shown that in the cooler districts it is best to light prune after the first plucking. In the warmer districts this is not advisable for the new shoots develop too long and quality is lost. In such cases, pruning after the third plucking is best.

Early pruning has a bad effect on the crop of the following year especially if only two pluckings are made. Pruning after the second plucking gives a greater yield in the following year.

Farmers are opposed to heavy pruning because they suppose that the bush thereby suffers from the cold.

Pests and Blights.

The Japanese tea gardens are not troubled with pests and blights to the same extent as North East Indian gardens. The severe winter has much to do with this freedom from attack. Most of the commoner Indian blights have been observed in Japan.

Red Spider is prevalent, especially if May is a dry month. It is treated with lime-sulphur solution. Green Fly comes in June and July after the second plucking. It spoils the quality of the tea by making the taste more bitter than is usual in the second season's teas. Kerosine emulsion is used as an insecticide. The Japan Hairy Caterpillar does damage in July and October. An insecticide made from soap solution and powdered chrysanthemum is used. The Red Borer does damage to the upper branches of the bush before April or May. This pest is counteracted by cutting off the branches affected. The Tea Looper appears in June, August and October. It lays its eggs in the pine tree bark and, in the vicinity of tea gardens where this pest is serious, the bark of such trees is stripped. The Faggot Worm is collected in August. The Tea Tortrix appears five or six times a year and, so far, no practical insecticide is available, but luckily there is a bee which devours this pest. The Tea Mosquito is unknown.

Of the blights, Blister blight occurs at variable times but usually in September or November. Brown blight appears after too liberal an application of manure. Shot Hole fungus, Red Rust, Tea Canker and Root Fungus (*rosellinia sp.*) all are known. The latter is controlled by uprooting the diseased bushes.

The Scientific Department at Makinohara issues convenient charts to farmers which show simply and diagrammatically the period at which each blight is likely to appear and the best treatment for combating the same.

Lime-sulphur and Bordeaux mixture are freely used by Japanese farmers who make up solutions in groups and use them together after the plucking season is finished. It has also been found advantageous to spray tea with Bordeaux mixture twenty or thirty days before plucking.

Manufacture of Tea.

One profound difference between the tea industry in Japan and that in India is that, whereas in India it is a new industry introduced after careful experiment and calculation, in Japan it is an industry which came to the country about a thousand years

ago and is now one of the essentials of the life of the people. To the cooly on the Indian tea garden the tea leaf is a foreign crop and tea a luxury, but, to the Japanese, it is part of his life and enters into his folklore. On this account the transformation of the tea leaf into tea is a process hemmed in by many customs and ideas of great interest to a person from the Indian tea districts where tea making if merely a commerical, scientific process.

First, the purely hand process of manufacture as practised in the Shizuoka tea districts will be described. Then an account will be given of the machine and the part machine, part hand processes. Tea manufacture in the Uji district will be described under a later section.

The Hand Process.—The leaf is steamed as soon as possible after it is plucked. The steaming is carried on by means of a simple apparatus consisting of a vessel containing boiling water which is covered by a cylinder with a bottom of bamboo matting. About a pound of leaf is put into the cylinder and covered with a wooden lid. The leaf is submitted to the action of the steam for a period varying from three to five minutes according to the quality of the tea. The better the quality the shorter is the steaming. Too long steaming darkens the leaf.

The steamed leaf is thrown on to a bamboo table near the steamer and fanned in order to cool it is quickly as possible. In most factories to-day, this cooling is done by a small electric fan although in the past a hand fan was employed.

The rest of the manufacture consists in rolling the leaf on a warm surface till it dries.

The rolling table consists of a shallow wooden tray, about six feet long and three feet wide, the bottom of which is composed of paper about three layers thick, patched in innumerable places till little of the original bottom is visible. Just under the paper is an iron plate not near enough to the paper to rob it of elasticity. The plate, which is warmed by a charcoal fire banked with the ash of rice straw, distributes the heat and prevents undue pressure on the paper.

These rolling tables are arranged round long rooms and it is a fine sight to see a row of sturdy Japanese stripped but for a loin cloth exhibiting their splendid physique as they roll the leaf. The rolling is not merely a mechanical process for the men take great interest in their work and have various legends connected with each part of the process.

At Kanaya, leaf is rolled in about three hours and during this period one man deals with about 8 lbs. fresh leaf. The temperature of the paper of the rolling surface is about 240°F. With poorer quality tea the leaf is rolled for a shorter time on a warmer surface. The paper bottoms of the rolling table can be heated to a considerably higher temperature than 240°F, although at 350°F the paper begins to burn.

For making the best quality tea, fresh leaf should contain about 76% moisture.

The rolling process is divided into four periods. The first period is called the *Tuju-kiri* (*lit.* dew removing) and lasts about thirty minutes. During this period the leaf is rolled very lightly and sometimes merely shaken so that, although it dries, no juice is lost by expression. At the end of this period the leaf contains about 68% moisture.

The second period is called the *Naka-age* (*lit.* mid period) and lasts about twenty-two minutes. This time is the mean time of many rollings. The roller himself of course does not work by the clock, for he understands the condition of the leaf and works accordingly. During this period the moisture is reduced from about 68% to 51%.

After the second period comes an interval and during this time the leaf cools a little, holes are patched in the paper bottom of the rolling tray and the tea maker rests. The average rest period is fourteen minutes.

The third period lasting about forty-five minutes is called the *Naka-mome* (*lit.* mid rolling) and during this process the moisture is reduced from 51% to 32%.

TUJU—KIRI
(REMOVING DEW)

NAKA—AGE
(MID PERIOD)

NAKA—MOME
(MID ROLLING)

SIANGE—MOME
(FINAL ROLLING)

HAND ROLLING TEA IN JAPAN.

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The final period of rolling lasting about thirty minutes is called the *Siange-mome* (*lit.* finish rolling) and by the end of this process the moisture is reduced to 17%.

It is all important that the moisture content should vary to a nicety with the hardness of the rolling, for, if the leaf is too dry, it greys and loses its lustre.

The four stages are aptly illustrated by the Japanese drawings reproduced by permission of Mr. T. Miyachi, the Director of the Government Tea Experimental Station at Kanaya.

The final drying is done in a series of paper trays arranged in a case on top of each other, much as the trays in a Venetian dryer are arranged. Here again the heat is obtained from a charcoal fire banked with ash. The final drying lasts for about an hour and is done at a temperature of 160°—180°F. The lower temperature is better. The trays are continually removed and the tea felt by an expert maker. As the tea dries the trays are re-arranged so that the tea goes to the cooler part of the drying case.

The best moisture content of a tea for export is considered to be 4%. Tea for home consumption is dried to about 10% moisture.

The leaf is sorted in a box measuring about two feet square which is moved in a rotary manner by means of electric motors. A similar box working like an Allyn's Breaker is used for breaking the leaf. Tea is seldom cut in Japan.

Machine Manufacture.—The Japanese farmer has an instinctive dislike to tea manufacture by machinery but he has been driven to the use of machines by the prohibitive cost of hand labour. Forty years ago a man rolled leaf for 25 to 30 sen (6*d.* to 7½*d.*) a day, but now his wages are about Yen 3 (6*s.*) a day.

The following is a description of the factory at Kanaya which is built and managed on ideal lines.

The steaming machine consists of a long flat box about six feet in length and three feet in width. Through this box an endless wooden rack moves from power given by a small steam engine. Steam from this engine is led into the box and the leaf is thus

submitted to a temperature of about 200°F. which is considered ideal. About 5 lbs. of leaf packed an inch thick passes through the steam box each minute. The leaf is fed into the box by a hopper and at the other end it falls on to a quickly revolving paddle wheel which throws it through the air about feet feet. This flight cools the leaf. Such a machine can steam about 2,400 lbs. of leaf a day.

If the leaf is steamed too long it darkens and becomes pasty in rolling and an inferior quality of tea results. If the steaming time is too short the colour of the leaf is green, which is a good property, but the taste and aroma of the tea are poor and the leaf cracks in rolling.

The rolling is carried out in four different machines which attempt to follow the motions of hand rolling. The first machine is called the *Soju-ki* (*lit.* rough rolling machine) and it imitates the light motion employed by the roller in the *tuju-kiri* period of hand rolling, when the leaf is shaken and rolled lightly in order that it shall dry. The *Soju-ki* consists of a stationary cylinder about four feet long and four feet in diameter. Inside are three sets of springy, fork-like instruments which are rotated by a central rod driven by an electric motor. The leaf is thrown about lightly by these forks and rolled against the sides of the cylinder.

Hot air is pumped into one side of the cylinder and exhausted from the other by a small electric fan. The temperature inside the box is kept at about 160° F. At one time the heat was supplied by a charcoal fire but it has since been discovered that the fumes from such a source are detrimental to quality.

The leaf is rolled in this machine for about thirty minutes and the moisture is reduced from about 76% to 60%.

The second machine is called the *Junen-ki* (*lit.* twisting or rolling machine). This machine is similar to the roller used in Assam except that the rolling table is not enclosed in box. Very small machines, about eighteen inches to two feet in diameter, are used and each roller takes 20 to 24 lbs. of leaf at the time. The *Junen-ki* gives a good look to the tea but does not make for quality. The moisture content does not change during this process.

The third machine is called the *Saikan-ki* (*lit.* re-drying machine). This consists of a rotating box and stationary vanes which toss the tea about and dry it. The temperature of the box is raised to 110°—120°F. by means of hot air and the leaf is thereby dried to about 28% moisture in fifteen or twenty minutes.

The fourth machine is called the *Seiju-ki* (*lit.* finish rolling machine). This consists of a long trough made of aluminium which is corrugated along the length of the trough. A wooden plunger similarly corrugated lightly moves backward and forward in the trough thus rolling the leaf and keeping the individual leaves all end on. The bottom aluminium plate is heated directly, from below, by means of a charcoal fire. By thus rolling the leaf at a temperature of 160°F. for thirty to thirty-five minutes, the moisture is reduced to 11%.

The tea is finally dried by thinly spreading in a paper trough warmed by charcoal in a manner similar to that employed with the troughs used in hand rolling. In one hour the moisture is reduced to about 4%.

In most of the machines iron is freely used with no apparent detriment to the quality of the tea because the tannin in the leaf does not combine with hot iron.

At this point it is convenient to follow and compare the rate of drying of the leaf by machine and hand manufacture for in order to make good tea the drying must be slow and regular.

	Machine manufacture.		Hand manufacture.
Raw leaf ...	76% moisture		76% moisture
First roll ...	59% „	*Tuju-kiri* ...	69% „
Second roll ...	59% „	*Naka-age* ...	51% „
Third roll ...	28% „	*Naka-mome* ...	32% „
Finishing roll ...	11% „	*Siange-mome* ...	17% „

Most tea farmers manufacture their tea partly by machine and partly by hand. It is common to machine roll till the leaf has a moisture content of about 50%, that is, somewhere about the *naka-age* stage. Here it is possible to stop the manufacture

for some time as is done between the *naka-age* and *naka-mome* periods in hand manufacture. The later stages of rolling are then done by hand.

Tea factories in Japan are all very small. The largest deal with about 12,000 lbs. of raw leaf a day. It is common for a factory to deal with 2,400 lbs. to 4,000 lbs. of leaf a day. The manufacturing periods are so short that larger factories are not economical, for with small factories the leaf has not to be carried far.

All the factories, however small, are lighted and driven by electricity. In fact the use of electricity even in the poorest cottages of remote villages in Japan is a matter for remark. The risk of fire is so great in the ordinary Japanese house, made as it is of paper and the lightest wood, that people are practically forced to use electricity merely for safety. Most of the electricity is generated by water power.

Many factories measure only about 36 feet by 25 feet and in this small area there may be four rollers, two finishers, a rack dryer and a leaf steamer.

Some farmers buy fresh leaf from tea growers who have no factory. When they are open to do this, they signify the fact by flying a flag with a recognised sign. The value of raw leaf naturally varies. At the present time the earliest leaf is worth about one Yen (2*s.*) per *Kan* (8 lbs.). Later leaf is worth about 70 sen (1/5½*d.*) and the end of the season leaf as little 30 sen (7½*d.*) per *Kan.*

Re-firing Tea for Export.

Most of the tea for export is bought in the districts and then taken to Shizuoka where it is re-fired by European and Japanese companies. There are about ten such companies in the city but only three or four export tea directly. It is only in the city of Shizuoka that the Japanese tea industry takes on the commercial aspect which is the predominant note of the industry in India.

Tea may be re-fired in iron pans or in baskets. At one time re-firing was carried out in small iron pans with five to seven lbs. of

tea at a time and the stirring was done by hand. Nowadays the tea is re-fired in huge godowns containing batteries of pans, each pan capable of dealing with twenty-five to thirty lbs. of tea. The pans are arranged in two rows, the front row lower that the back and the stirring is done mechanically. First the tea is fired in the upper pans which are heated with coal or charcoal. After firing for thirty minutes or an hour the tea is transferred to the lower pans which are cold. The stirring is continued in these pans and by this means a lustre is given to the leaf.

In former times, tea for export was "faced" in the cold pans with Prussian Blue and talc.

The best tea is re-fired in baskets in a manner similar to that employed by the Chinese and which may be seen in the *hongs* at Canton, Shanghai and almost any city in Southern China.

The baskets, which are made of solidly woven split bamboo, are about four feet high, two or three feet wide at each end and are tapered to the middle. At the waist of the basket is placed a removable bamboo tray, about a foot in diameter, and on this tray, four or five lbs. of tea, thinly spread, is dried. Below the tray is a small charcoal fire banked with ash.

Every five or ten minutes the basket is carefully removed from the fire and the tea stirred by hand. This is a process which must be carried out with care, for if a tea leaf drops through the tray into the fire the smoke from its burning destroys the flavour of the tea above. The process is laborious but the tea is the best and as a compromise with commercialism some re-firers carry out the first part of the firing in iron pans and the latter part in baskets.

Whilst pan firing produces a broken tea, basket fired tea is very little broken and contains whole shoots beautifully twisted into what are known as "spider's legs."

The tea is sorted by basket sieving and the removal of stalk is done by hand. The machine sorters used in Indian factories are apparently not used to any great extent in Japan. A sample of pan fired tea sent from Shizuoka to Tocklai was found to contain 2% moisture. Such a state of dryness would spoil the quality of

Indian black tea which keeps best at a moisture content of about 6%.

The tea boxes for export are square, lead lined and hold about 80 lbs. of tea. About 75% of the Japanese green tea which is exported is pan fired. Green tea only keeps about two years and in this respect differs from black tea which, if carefully manufactured, keeps for several years.

Uji Tea.—The teas from the Uji district stand with regard to the Japanese tea industry much as Darjeeling teas do with the Indian tea industry. The Uji gardens which date from the close of the twelfth century have always been considered the best in the Empire and Uji tea known as Gyo Kuro or Pearl Dew is renowned the world over.

Uji should be seen in the months of April and May, for then the country side takes on an extraordinary appearance owing to the vast stretches of artificial shading which cover the tea bushes. The shading, which is put up about three weeks before plucking, is composed of grass and rice straw supported by bamboos at a height of about six feet. It is very dense and the sides of the area are also shaded.

In the Uji district the first plucking is ten or fifteen days later than in Shizuoka owing to the colder nights in the former place which retard the growth of the leaf. As soon as the plucking is complete the shading is removed because it is injurious to the health of the bush.

The best tea is made from the centre of the garden, for the edge bushes are touched by passers-by and this is supposed to rob the tea of quality. The finest quality is obtained from the oldest bushes, and it was at one time believed that a bush needed to be 50 or 60 years old before it could yield good tea. Research, however, has shown that 30-year old bushes give quite good tea although the tea from young bushes (*e.g.* 10-year old) is poor.

As soon as possible after the leaf is plucked it is steamed. Only about 4 oz. are steamed at a time, for seven to ten seconds. The rolling is of course done by hand, at a low temperature. In

very special cases tea may be rolled for as long as fifteen hours at a temperature of 140°-160F°. The tea thus produced has a fine appearance but is poor in taste and aroma and has not the fragrance of a tea more quickly made. The price of such a tea may be as much as Yen 30(£ 3) a pound. Apart from these exceptional teas, the maximum value for Gyo Kuro is from Yen 15 to 20 (30*s.* to £2) a pound. Gyo Kuro powder brings about Yen 3 (6*s.*) a pound.

The infusion of Gyo Kuro is made with water which has boiled and cooled and it is drunk slowly and thoughtfully from very small cups. Gyo Kuro is looked upon by the Japanese in much the same way as an epicure looks upon a wine of rare vintage.

It is to be expected that farmers in the Shizuoka district would attempt to improve the quality of their tea by shading. It is a common sight to see individual bushes covered with straw much in the same manner as a round haystack is covered in England. The cover actually lies on the bush. This covering holds back the growth and produces a tea of beautiful colour but poor in flavour and taste. Such teas are useful for blends and are known as *Kabusei-cha* (*lit.* covered tea). In some places considerable areas are covered in a manner similar to that adopted in the Uji district, but the results are not the same.

The question of the material used for shading is of great practical interest. In Shizuoka only fresh rice straw is used, other coverings are considered to be inferior. The reason for this practice has not yet been found, although it is possible that the alkalinity of the straw may give the leaf a good colour. In the Uji district this question is receiving much attention.

Powdered Tea.--Powdered tea or *Ten-cha* (*lit.* milled tea) as the Japaneae call it, is a ceremonial tea. It is cultivated in the same manner as Gyo Kuro but the manufacture is different. Only the finest leaves are used and these are thoroughly cleaned and separated from the stalk by means of chop sticks. The leaf is well steamed and not rolled but dried in long, low drying rooms at a low temperature. As the leaf dries the coarser leaves are removed until eventually only the finest leaves remain.

Since powdered tea is very hygroscopic the whole leaf is stored and is ground but a short time before the ceremonial drinking. The powdering is done in a stone mill with care and slowness and a great deal of ceremony.

Ten-cha is made with well cooled water which has been well boiled, for if the water is too hot the taste of the tea is bitter. The tea is vigorously stirred with a bamboo whisk and, whilst it is still bubbling, is swallowed, powder and all.

Patent-Teas.—Round the town of Uji various patent teas are manufactured and put up in neat tins and packed in attractive looking boxes. One is a Milk Tea which contains extracts of both milk and tea. Another is Lemon Tea. To quote the writing on the packet (both in English and Japanese)—"This 'Lemon Tea,' the principal constituents of which are our patented tea essence and selected sugar with an addition of lemon being made through the dexterous application of the company's own special method that the modern science can ever take pride in, is a sanitary drink best fitted both for reception and domestic use. A spoonful of the 'Lemon Tea' and ample water, either hot or cold poured into a tea-cup will make lemon tea full of flavor and just to taste."

The most interesting production is *Cha-sei* (tea extract) which is put on the market in a tin shaped something like a pepper box. By simply sprinkling the extract into hot water "a beverage with all the aroma, color and taste of freshly steeped tea" is obtained.

The detailed preparation of these patent teas is naturally a trade secret. The tea extract is prepared from tea infusion which is evaporated in vacuo and centrifuged to remove the gummy matter. Unless the gums are removed, the tea extract will not powder well and is very hygroscopic. As it is these extracts deteriorate on exposure to moist air.

Wages and Expenditure.

In Japan, as in the rest of the world, the cost of labour has increased enormously during the past few years. Although at first the tea farmer suffered from this increase he soon adapted himself

TEA FACTORY AT KANAYA, JAPAN.

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to new conditions in order to cut down his costs. He now uses cheaper manures, employs scissors for plucking the leaf and manufactures his tea either wholly or partly by machine in a factory run by electricity.

Below is given the cost of a well run, good quality tea farm.

In one year an acre of tea requires :—

For cultivation	...	30 days work	(men).
manuring	...	10 „	„
careful pruning	...	12 „	„
first plucking	...	135 „	(women).
second „	...	51 „	„
third „	...	20 „	„

The cost of labour is ...	...	Yen 341
The cost of manure is ...	...	„ 205
Total	...	Yen 546

For manufacture the following expenditure is necessary :—

Pine wood (for steam)		...	Yen 45
Charcoal (for rollers)...		...	„ 45
Paper, paste, etc. ...		...	„ 20
Hand rolling	first plucking	...	„ 163
	second „	...	„ 60
	third „	...	„ 20
	Total	...	Yen 353

The total cost for cultivation and manufacture was Yen 899, and the tea produced was about 1,640 lbs.

In 1921, tea sold at 50 sen per pound so that the season's working showed a loss of Yen 79. In 1923 the price of tea had improved to 70 sen per pound and as the cost of labour had not risen, the season's working should show a profit of Yen 249.

The Quality of Japanese Tea.

Chemists in Japan, like these in India, are making a special study of the quality of tea. Before quality can be improved

scientifically it is first necessary to ascertain on what factors quality depends. In North East India it is believed that the quality of tea depends largely on the tannin content of the leaf and a rough correlation between this value and the price of the tea has been noticed. This refers only to teas of the plains which are sold for cup colour, pungency, liquors and briskness. The quality of Darjeeling teas does not depend so much on tannin for they are sold for aroma and flavour, qualities independent of the tannin content of the leaf but which may possibly vary with it.

The quality of green tea is based on properties quite different from those on which the quality of Indian black tea depends. With green tea, the price generally varies inversely as the tannin content of the leaf. The finest Gyo Kuro is rich in protein bodies and poor in tannin. As important as these two factors is the amount of flavone and anthocyan in the leaf. The quality also varies with the caffeine content of the leaf which is highest in young leaves.

A brief description of the classes of substances which influence the quality of green tea is of interest.

Proteins are manufactured by the leaves of the plant from nitrogenous bodies taken in by the roots and from carbohydrates. Hence a good supply of nitrogen to the soil increases the protein content of the plant, and for this reason heavy nitrogenous manuring is carried out in Japan.

The pencentage of crude protein in the leaf is calculated directly from the nitrogen content. Of 462 samples of good Japanese Exhibition tea every one contained over 30% crude protein. The best samples of tea gave the average value shown below.

Average nitrogen	5·68%
Average crude protein (*i.e.* N × 6·25) ...	35·50%

With tea grown in North East India the nitrogen content is somewhat lower than that of Japanese teas, varying between 5·0% and 5·25% which give crude protein values of 31·25% and 32·81% respectively. Heavy nitrogenous manuring in India

increases the crude protein in the leaf just as it does in Japan. The effect of crude protein on green tea infusions is to make good liquors.

Tea tannin is one of the large group of bodies known generally as tannins. The tannins occur in the cell sap of plants yet separated from the protoplasm by which they are precipitated to form the substance known as leather. Tannin has a pungency which is detrimental to the quality of green tea.

Anthocyan and flavones are two classes of bodies closely related chemically. Anthocyan is formed in the leaf under the influence of light of high intensity and it has a reddish colour. Since anthocyan has a bitter taste which detracts from the quality of green tea, the best tea is made from shaded bushes. Flavones are yellow bodies which are easily converted into anthocyan.

The yellow colour is a valued quality in green tea but the flavone itself is tasteless. Neither flavones nor anthocyan have yet entered into the question of the quality of Indian black teas.

Caffeine is the alkaloid which acts as the stimulant in tea. It is not one of the qualities which is priced by the taster for it is colourless, odourless and only very slightly bitter. Yet the better teas are usually rich in caffeine since the younger shoots which make the best tea, are richer in this substance than older shoots. Caffeine varies from about 2% in the poorest green tea to 4% in Gyo Kuro. Most Indian black teas contain more than 4% caffeine and the average is about 4·5%.

In pricing Japanese green tea the following points are observed. The leaf colour most sought after is a dark green. Light green is the next best, followed by a blackish green and then by a yellow. A brown or "dead" colour, as it is technically known, red and reddish black colours are the worst.

So far as style is concerned, the market changes. At one time straight leaf sold well but now a well twisted tea is called for.

The colour of the infusion is examined best in reflected light. The infusion should be greenish yellow but the green should not be too dense. Brown, red or black colours are associated with low prices.

The infusion must not taste bitter.

As was mentioned above, the crude protein content of the leaf is a measure of quality. Thus first, second and third qualities of Gyo Kuro gave crude protein values of 42·45%, 41·16%, 40·49%, respectively. These values refer of course to percentages calculated on the dry leaf.

With Sencha teas of the Shizuoka district the protein content is much higher in the first plucking than in subsequent pluckings. The values for the second and third pluckings are about equal, but the quality of the third plucking is reduced by other factors for much old leaf and sometimes light prunings are included in the August leaf. The actual values are shown below.

Sencha, first plucking—crude protein ... 35·81%
„ second „ — „ „ ... 25·76%
„ third „ — „ „ ... 25·98%

Tea is usually first plucked at the beginning of May. The best tea is obtained from pluckings made on the 15th, 16th and 17th of the month and after this date the quality suddenly changes. This change is due to several factors, but the table below shows the sudden drop in crude protein after the middle of the month.

Plucking date.	Crude protein.
April 27th	32·4%
29th	31·7%
May 1st	32·9%
4th	30·9%
6th	31·9%
8th	30·5%
10th	29·1%
12th	30·0%
14th	28·6%
16th	28·2%
18th	24·9%
20th	24·5%
23rd	23·5%

The work with regard to tannin has not yet been so denfiitely studied. Generally, poor teas contain more tannin than better teas of the same plucking, yet the earlier teas which are better than later ones contain more tannin than the later ones. Thus in Shizuoka the values below were given.

Tea plucked April 27th—tannin ... 12·85%
„ „ May 23rd — „ ... 8·46%

The chief measure of the quality of Japanese tea is the content of anthocyan which usually varies as the tannin content. There are however many cases when a high tannin goes with a low anthocyan content.

The anthocyan test has been worked out at the Kanaya and is now used as an estimate of quality with absolute confidence. In a cup of 200 c.c. capacity 2·6 grammes of tea are infused for five minutes. To the infusion a few drops of dilute hydrochloric acid are added and, if anthocyan be present, a red coloration is obtained. According to the depth of this colour, so the anthocyan content. By means of a scale of colours made from known solutions, the amount of anthocyan in the infusion may be read off at a glance. One part in 10,000 of anthocyan gives a bitter taste and makes the quality of the tea poor. Gyo Kuro contains no anthocyan.

Flavones are closely related to anthocyan and may be converted into anthocyan by reduction with hydrogen. Thus although a good tea may give no red coloration with hydrochloric acid, the addition of a little magnesium, which evolves hydrogen, reduces the flavone to anthocyan and within twelve hours a red colour is obtained.

To revert to the question of tannin and anthocyan it must be mentioned that tannin sometimes goes with quality in green teas. Thus a May tea of good quality may contain little anthocyan and much tannin and a June tea, containing just the same quality of tannin, will be a poor quality tea because of a large anthocyan content. The question is extremely complicated and is still being studied by the Japanese chemists. It is believed that about 15% tannin is the best content for green tea.

M. Torumi has studied the relationship between anthocyan and flavone in the tea leaf and has lately published the results of his investigations. He selected 167 bushes and took the leaves in May and July and found that the anthocyan was always much greater in July than in May and that the degree of variation goes with the original amount of anthocyan present. The flavone varies invensely as the anthocyan.

The same chemist studied the relationship between the anthocyan and the tannin content of the leaf with the following results :—

Sample.	Anthocyan.	Tannin.
No. 1	1 part in 1,000	21·54%
No. 2	1 ,, 10,000	16·26%
No. 3	1 ,, 64,000	15·65%
No. 4	nil.	18·32%

M. Torumi also analysed the tea leaf at the end of each period during machine manufacture with the following results. The values are calculated on dry leaf.

——	Water %	Tannin %	Ether soluble matter %
Fresh leaf ...	77	15·2	6·78
After steaming ...	77	...	...
First rolling ...	59	12·83	2·91
Second ,, ...	59	...	...
Third ,, ...	28	12·27	2·90
Fourth ,, ...	11	12·18	3·68
Final drying ...	4	...	...

The drop in tannin content during the first rolling may be due to the considerable heating which the leaf undergoes at this stage when it is rich in moisture.

There is very little change in the other constituents of the leaf, *viz* :—fibre, ash, soluble matter, except the soluble solids which slightly increase as is shown below. The same differences are shown through the hand rolling process, except in so far as the solubility of the tannin is concerned.

The first table shows the variation in solubility of total solids in tea leaf as manufacture proceeds. The figures give the quantity of soluble matter obtained by infusing 2·6 gms. of tea in a cup of 200 c.c. for five minutes.

——	Machine made.	Hand made.
Fresh leaf ...	0·45 gms. solids per cup	0· 5 gms. solids per cup
First roll ...	0·62 ,, ,, ,,	0·49 ,, ,, ,,
Third ,, ...	0·71 ,, ,, ,,	0·76 ,, ,, ,,
Final ,, ...	0·78 ,, ,, ,,	0·76 ,, ,, ,,

The second table shows how the solubility of the tannin under conditions similar to the above is increased by rolling, both with machine and hand made tea.

——	Machine made.	Hand made.
Fresh leaf ...	0·089 gms. tannin per cup	0·089 gms. tannin per cup
First roll ...	0·170 ,, ,, ,,	0·070 ,, ,, ,,
Third ,, ...	0·210 ,, ,, ,,	0·190 ,, ,, ,,
Final ,, ...	0·210 ,, ,, ,,	0·200 ,, ,, ,,

The interpretation of these figures has not yet been given.

Some years ago, before the market for Indian black tea was firmly established, merchants who sold China teas, black and green, claimed that these teas did not contain so much tannin as Indian teas and were therefore preferable. China tea grown in India contains about as much tannin as Assam and Burma teas. Thus below is shown the tannin content of the green leaf from the various kinds of bushes plucked in August.

Burma leaves ...	...	26·25% tannin
Assam ,, ...	...	24·50% ,,
China ,, ...	...	24·70% ,,

China bushes grown in Japan, however, show much lower tannin percentage, the average being about 15%.

In the manufacture of black tea much tannin is lost through decomposition into other substances. In one case at Tocklai the following change was observed :—

Fresh leaf	contains	...	22·20% tannin
Withered leaf	„	...	22·20% „
Fermented	„	...	12·88% „
Dried tea	„	...	11·99% „

With Japanese green tea the drop in tannin content is not nearly so great as will be seen from the table, reproduced from above, dealing with machine made tea.

Fresh leaf	contains	...	15·2 % tannin
After first rolling	„	...	12·83% „
„ third „	„	...	12·27% „
„ final „	„	...	12·18% „

Analyses of Japanese green teas made at Tocklai gave the following tannin percentages.

Gyo Kuro ...	...	9·49% tannin
Sencha ...	...	11·09% „
Material for powdered tea	...	9·82% „

These values agree with the average of many estimations made in Japan. Thus the tannin content for the average Gyo Kuro is 9·5% and for the average Sencha 11·5%.

Below are given some analyses of various teas made at Kanaya. The values are percentages calculated on dry matter.

The first table shows figures for Gyo Kuro teas of the first, second and third quality.

Quality of sample.	Moisture.	Total Nitrogen.	Caffeine.	Soluble matter.	Ether Extract.	Crude ash.	Soluble ash.
First ...	7·78	6·79	3·50	42·66	4·15	6·70	5·32
Second ...	8·53	6·58	3·75	38·40	3·28	6·82	5·22
Third ...	7·18	6·47	3·95	43·93	5·40	6·83	5·79

The next two tables show the analyses of Sencha teas of different pluckings manufactured by machine and by hand. The total nitrogen decreases as the season advances. The soluble matter, the ash and soluble ash increase and the caffeine is fairly constant.

Sencha–Hand Manufactured at Kanaya.

Plucking.	Moisture.	Total Nitrogen.	Caffeine.	Soluble matter.	Ether extract.	Crude ash.	Soluble ash.
First ...	5·27	5·73	2·22	47·24	3·60	5·01	4·42
Second ...	6·35	5·26	2·19	43·48	3·69	5·32	4·27
Third ...	4·66	4·11	1·96	42·52	3·37	5·33	4·27
Fourth ...	5·58	4·15	2·09	37·14	4·10	5·47	3·82

Sencha–Machine Manufactured at Kanaya.

Plucking.	Moisture.	Total Nitrogen.	Caffeine.	Soluble matter.	Ether extract.	Crude ash.	Soluble ash.
First ...	5·53	5·12	2·39	42·60	4·32	5·05	4·30
Second ...	5·22	4·31	2·17	43·76	5·23	5·38	4·44
Third ...	6·08	4·00	2·32	45·16	4·54	5·69	4·46

The analyses of Bancha teas, which are largely composed of old leaves and light prunings, are shown in the following table.

Bancha–Machine Manufactured at Kanaya.

Sample.	Moisture.	Total Nitrogen.	Caffeine.	Soluble matter.	Ether extract.	Crude ash.	Soluble ash.
I	6·06	3·82	1·96	40·02	4·31	5·34	4·15
II ...	7·90	3·53	1·85	40·75	5·75	5·75	3·93

The final table gives a fairly full analysis of the tea leaf showing its change in composition as the season advances.

The change in the composition of Sencha Tea Leaf as the Season advances.

Values are calculated on the dry leaf.

Date.	Average length of shoot.	Weight of shoot.	Crude protein. %	Crude fibre. %	Ash. %	Caffeine. %	Tannin. %	Soluble matter. %	Total Nitrogen. %
April 27th	1·6 cm.	0·10 gms.	32·4	8·8	5·7	3·1	12·9	43·8	6·2
„ 29th	2·18 „	0·14 „	31·7	9·1	5·4	3·2	12·6	45·7	6·0
May 1st	2·6 „	0·17 „	32·9	7·4	5·4	2·9	11·7	47·2	6·1
„ 4th	3·0 „	0·21 „	30·9	9·7	5·5	3·2	11·4	47·7	5·9
„ 6th	3·4 „	0·28 „	31·9	11·0	5·3	2·5	10·4	47·0	5·7
„ 8th	4·1 „	0·32 „	30·5	11·7	5·4	2·8	10·3	46·9	5·7
„ 10th	4·4 „	0·35 „	29·1	12·9	5·4	2·8	11·3	47·0	5·5
„ 12th	5·0 „	0·48 „	30·0	14·8	5·4	2·7	10·3	44·0	5·4
„ 14th	4·8 „	0·45 „	28·6	12·7	5·4	2·4	10·4	44·3	5·2
„ 16th	4 8 „	0·46 „	28·2	14·1	5·2	2·3	9·5	43·0	5·1
„ 18th	4·6 „	0·45 „	24·9	14·5	5·2	2·0	8·4	41·5	4·4
„ 20th	5·5 „	0·52 „	24·5	12·4	5·3	2·2	9·0	42·7	4·6
„ 23rd	4·2 „	0·70 „	23·5	15·9	5·3	2·2	8·5	40·9	4·4

Naturally the size and weight of the shoot increase as does also the crude fibre which is a measure of the toughness of the leaf. Both the crude protein and soluble matter fall after the middle of May and both are closely connected with quality. The tannin and caffeine both show a more of less steady fall as time goes on. The ash is fairly constant.

Tea Ceremony.

In Japan, tea making and drinking have a deeper meaning than in Europe. Tea enters into the lives of the people and takes on a significance which is almost religious. Okakura Kakuzo in a publication called "The Book of Tea" writes of the subject as follows.—"Tea began as a medicine and grew into a beverage. In China, in the eighth century, it entered the realm of poetry as one of the polite amusements. The fifteenth century saw Japan enoble it into a religion of aestheticism—Teaism. Teaism is a cult founded on the adoration of the beautiful among the sordid facts of everyday existence. It inculcates purity and harmony, the mystery of mutual charity, the romanticism of the social order It is essentially a worship of the Imperfect, as it is a tender attempt to accomplish something possible in this impossible in thing we know as life."

The origin of tea is the subject of a strange myth. It is said that Dharuma, a sage, during one of his prolonged periods of meditation, found that he was becoming drowsy. Seizing his offending eyelids he cut them off and cast them from him, and where they fell a plant grew (the tea plant) from whose leaves can be prepared a drink which drives away sleep.

The Chinese began to drink tea in the sixth century A.D. and soon after we have Chinese poets writing in the following strain—"The first cup moistens my lips and throat, the second cup breaks my loneliness, the third cup searches my barren entrail but to find therein some five thousand volumes of ideographs. The fourth cup raises a slight perspiration,—all the wrong of life passes away through my pores. At the fifth cup I am purified; the sixth cup calls me to the realms of immortals. The seventh

cup—ah, but I could take no more! I only feel the breath of cool wind that rises in my sleeves. Where is Horaisan *? Let me ride on this sweet breeze and waft away thither."

In China, Tea passed through several periods which may be roughly divided into three stages; the Cake-tea which was boiled, the Powdered-tea which was whipped and the Leaf-tea which was steeped.

Japan closely followed Chinese civilization and knew tea in all its three stages and tea is mentioned in Japanese history as early as 729. In 801 tea seeds were brought to Japan and planted at Yeisan and later, with greater success, at Uji. The use of steeped tea of the later China is comparatively recent in Japan although now it has replaced powdered tea which is only used on ceremonial occasions, but is still regarded as the tea of teas.

As Western ideas have been adopted and old Japan has disappeared, the tea ceremony has lost much of its significance. When Teaism was in its prime, the tea room was a most important building and was apart from the house in a garden tastefully planted with shrubs.

The guests wash their hands before entering and leave their shoes and their swords outside. They then enter the tea room before their host who kneels at the door. The guests in turn kneel before the *Tokonoma* which, to a Westerner, resembles a low altar, and is the direction which one naturally faces, much as in western rooms one faces the fireplace. The *Tokonoma* consists of a low shelf let into a recess in the wall. On the wall is a *Kakemono* or hanging picture which rolls up like a map when not in use. The subject of the picture is something simple and austere and below it flowers may be arranged.

The host brings in the tea-making utensils and the fire and sets everything ready with much ceremony. When this is finished the guests retire and the host may arrange a fresh decoration in the *Tokonoma*.

When the water boils, the guests are recalled by means of a gong and food and *saké* are placed before them. Finally the

* The Chinese Elysium.

powdered tea is taken from its silken bag and placed in the tea bowl. On it is poured hot, but not boiling, water. The mixture is frothed with a whisk and then passed to the chief guest who drinks it ceremoniously with a loud sucking noise. The bowl is then passed on and the others drink in turn. When this ceremony is finished, the guests leave.

The greatest master of tea ceremony was Rikiu who lived in the sixteenth century under the patronage of Taiko-Hideyoshi. The enemies of Rikiu accused him of treason towards his patron and the Tea-master was condemned to death, but was granted the honour of dying by his own hand.

The last tea of Rikiu is described in "The Book of Tea" as follows:—"On the day destined for his self-immolation, Rikiu invited his chief disciples to a last tea ceremony. Mournfully at the appointed time the guests met at the portico. As they look into the garden path the trees seem to shudder, and in the rustling of their leaves are heard the whispers of homeless ghosts. Like solemn sentinels before the gates of Hades stand the grey stone lanterns. A wave of rare incense is wafted from the tea-room; it is the summons which bids the guests to enter. One by one they advance and take their places. In the *Tokonoma* hangs a *Kakemono*,—a wonderful writing by an ancient monk dealing with the evanescence of all earthly things. The singing kettle, as it boils over the brazier, sounds like some cicada pouring forth his woes to departing summer. Soon the host enters the room. Each in turn is served with tea, and each in turn silently drains his cup, the host last of all. According to established etiquette, the chief guest now asks permission to examine the tea-equipage. Rikiu places the various articles before them with the *Kakemono*. After all have expressed admiration of their beauty, Rikiu presents one of them to each of the assembled company as a souvenir. The bowl alone he keeps. 'Never again shall this cup, polluted by the lips of misfortune, be used by man.' He speaks, and breaks the vessel into fragments.

The ceremony is over; the guests with difficulty restraining their tears, take their last farewell and leave the room. One only,

the nearest and dearest, is requested to remain and witness the end. Rikiu then removes his tea-gown and carefully folds it upon the mat, thereby disclosing the immaculate white death robe which it had hitherto concealed. Tenderly he gazes on the shining blade of the fatal dagger, and in exquisite verse thus addresses it :

'Welcome to thee,
O sword of eternity !
Through Buddha
And through Dharuma alike
Thou hast cleft thy way.'

with a smile upon his face Rikiu passed forth into the unknown."

SKETCH MAP OF SOUTH SYLHET

SCALE 1 INCH = 8 MILE

TEA GARDENS MARKED IN RED

TEELA LAND SHADED

TIPPERAH

CACHAR

Surma R.

Kusiyara R.

Barak R.

Khowai R.

Manu R.

Dholai R.

Juri R.

Longai R.

Sonai R.

BADARPUR Junc.

Chargola Stn.

Bhangar Stn.

Karimganj Stn.

Latu Stn.

Barlekha Stn.

Dakshinbhag Stn.

Juri Stn.

Tilagarh Stn.

Shamshernagar Stn.

Shaistergunj Stn.

Chhatiain Stn.

Itakhola Stn.

FENCHUGANJ

MANUMUKH

HABIGUNJ

HAILHAOR

HAKALAKI BHEEL

Madanpur

Shahbazpur

Dakhingul

Eraligul

Samanbhag

Dhamai

Sonarupa

Champa

Kapnahahar

Pathini

Clevedon

Ghazipore

Kaliti

Rangichara

Saguenah

Phillollah

Rajkie

Lipiagul

Medli

Firinti

Tilbhoom

Baitakhal

Hajikhira

Isabheel

Magurdchara

Katinagar

Bhubrighat

Adamtila

Longai

Chandkhira

Bidyanagar

Chargola

Mukam

Kalacherra

Dullabcherra

Lalacherra

Balicherra

Fanai

Gumbhira

Kekrajul

Ulurchara

Silloah

Bylna

Anipur

Indranagar

Uttarbhag

Korimpur

Etah

Udna

Parbutpur

Rajnagar

Langla

Sripar

Kularua Stn.

Holoi

Hingajea

Mintesar

Chatakii

Mazdehee

Chila

Tagacherra

Mertinga

Ninagar

Dauracherra

Shamshernugger

Kannyhatti

Deocherra

Chatlapore

Ulunugger

Mirzapore

Rasidpur

Satgaon

Haraora

Daragaon

Gazili

Amrail

Hugli

Parkul

Rajghat

Deapston

Kakia

Phulcherra

Kalighat

Madanpur

Gobindpur

Patra Khola

Dholai

Kurma

Lalchand

Deundi

Luskerpore

Chandpur

Chandicherra

Amo

Satchuri

Sundra

Telianara

Rema

Bylna

Sillogh

LUSKERPORE VALLEY

BALISERA VALLEY

DHOLOI VALLEY

LANGLA DISTRICT

JURI VALLEY

LONGAL VALLEY

CHARGOLA VALLEY

IMPERIAL ART COTTAGE, COLOOTOLA.

4½ RATU SARKAR LANE, CALCUTTA.

SOIL SURVEY NOTES.

SOUTH SYLHET.

BY

P. H. CARPENTER AND H. R. COOPER.

The tea area of South Sylhet consists of eight roughly parallel spurs running north from the Tipperah Hills. The seven valleys between these spurs constitute the seven sub-districts of South Sylhet.

E. H. Pascoe, of the Geological Survey of India, maps these spurs as forming part of the Tipam series of rocks, which he describes—. "The chief component of this series is a thick-bedded, massive, usually well-jointed sandstone, the texture varying from medium to decidedly coarse or conglomeratic. A soft, iron-stained, current-bedded sand-rock, exactly similar to that in the Burmese Irrawadian, is very typical. Ferruginous bands are not so frequent as they are in the Burmese rocks. Ferruginous conglomerate exactly similar to that of the Irrawadian is described by Mallet from two localities and was seen by myself in one of them ; it characterises the lower horizons of the Tipams. The matrix is a highly ferruginous sand which, when the pebbles are of soft clay, weathers to a cellular rock identical with the one described from Yenangyaung. Clunchy clay, often of a greenish or reddish tinge, is to be seen, but is much subordinate to the sandstone. Small patches of coal, mostly lignitic, sometimes occur in the Tipams, but it is not plentiful."

Maclaren, in "Geology of Upper Assam," describes the rocks of the Tipam series as they occur in Upper Assam.

"In their most characteristic development they are grey, or greenish-grey, speckled sandstones made up of quartz, felspar, a white mica, biotite, hornblende and chlorite, the last when abundant giving to the rock its greenish colour. They weather to dull grey boulders, and occasionally, by decomposition of the ferromagnesian constituents, to a rusty brown. Thin bands of clays and shales—

brown, green, and bluish grey—occur, but are rare. Lignite bands are not uncommon, and the formation as a whole is characterised by the abundant presence of semi-carbonised, semi-silicified wood. False bedding is everywhere apparent, the lines of bedding being often picked out on weathering by thin strings of half-inch pebbles."

These rocks of the Tipam series form the foot-hills (with breaks near Sonari and around Digboi) of the mountains which enclose the Valley of the Brahmaputra (including its tributary the Surma) on all sides, and therefore must be very largely the source of the new alluvium of the whole valley, in which sandy soils with little clay predominate.

As they occur in the teelas of South Sylhet the soils are red sands, containing very high percentages of coarse and fine sand, but generally with a significant percentage of clay (10 to over 20 per cent), while the particles of intermediate size (silt and fine silt) are commonly present in small quantity only. Such a soil could not have been deposited from water but must have been formed in its present position, so that the characteristic South Sylhet teela soil may be looked upon as formed by weathering of the original Tipam sandstone. As this rock is classed as tertiary it is (compared to the new alluvium) of great age, and has suffered leaching for a very long period. As might be expected, therefore, poverty in lime, phosphoric acid, and potash generally characterises both these soils and also the newer alluvium directly derived from them.

Intermixed with the red sandy teelas and plateaux are flats of recently deposited sands (from which clay has been very largely carried off by the running water which deposited the sand,) and also the characteristic "bheel soils" of the district. These bheels were land-locked lakes among the teelas. After draining, flats of sandy or medium but more often clayey soils remain, which in all cases have been enormously enriched by deposits of peat, and in some cases the soil itself to a very great depth is nearly pure peat.

The tea gardens are generally scattered along the fringes of the spurs, where flats are more common and the teelas generally are low and of reasonably gentle slope. In the middle of the

spurs the teelas generally slope too steeply for convenient cultivation of tea, while transport would also be difficult.

The spur between the Juri and Longai Valleys is exceptional in this respect, for here the central high ridge is narrow, and low teelas, among which bheel flats abound, occupy a wider strip of the west side of the Longai Valley.

No tea occurs between these spurs and the Surma River, because the new alluvium of this land is too low lying. It is much occupied by streams and shallow lakes, while the cultivation is chiefly rice.

The climate resembles that of the Assam Valley, but being further south it is generally hotter, particularly at the western end of the district; and this higher temperature is very marked during the spring when droughts are relatively frequent and do very considerable damage to tea, both on the sandy and on the bheel soils.

Types of Soil occurring in South Sylhet.

Mechanical analysis divides a soil into particles of different ranges of size, these being, in order of coarseness

1. Coarse sand.
2. Fine sand.
3. Silt.
4. Fine silt.
5. Clay.

According to the order in which these constituents occur we divide all soils into 120 "types."

The following table shows rough percentage compositions of common types of soil of South Sylhet.

	A.	B.	C.	D.	E.	F.	G.
1. Coarse sand ...	40	30	30	40	50	5	5
2. Fine sand ...	30	40	20	27	25	30	10
3. Silt ...	9	9	15	15	15	15	15
4. Fine silt ...	6	6	10	15	9	20	30
5. Clay ...	15	15	25	12	1	25	40
Soil type ...	12534	21534	15234	12354	12345	25431	54321

In soil A, No. 1 constituent, coarse sand, forms the greatest part of the soil (40%), with No. 2 constituent (fine sand 30%) next, and these are followed in order by No. 5 constituent (clay 15%, and) No. 3 constituent (silt 9%), with No. 4 constituent (fine silt 6%) last.

When we write down that this soil is of the "1, 2, 5, 3, 4 type" it tells us the order in which the constituents occur and therefore gives a rough but very useful idea of the mechanical analysis of the soil.

Soil B is almost exactly the same as soil A, except that fine sand is this time greater than coarse sand, so soil B is of 2, 1, 5, 3, 4 type.

Similarly soil C is of 1, 5, 2, 3, 4 type. This type is clearly related to the 1, 2, 5, 3, 4 type, being derived from it by a relative increase in clay at the expense of fine sand.

Soil D is of 1, 2, 3, 5, 4 type, which is derived from the 1, 2, 5, 3, 4 type by an increase in silt at the expense of clay.

These four types	... 1,2,5,3,4.
	2,1,5,3,4.
	1,5,2,3,4.
	1,2,3,5,4.
with the almost exactly similar types	1,2,5,4,3.
	2,1,5,4,3.
	1,5,2,4,3.
	1,2,3,4,5.

are the common types occurring among South Sylhet teelas.

All contain large quantities of sand, and (with the exception of the last which is of rare occurrence) all contain significant and sometimes high percentages of clay, particularly in the subsoil.

Soils recently deposited from suspension in water do not contain both coarse sand and also clay in large quantities.

If the water is originally running fast enough to carry coarse sand, it drops it as soon as the water slows up on reaching a gentle slope, while the finer constituents are carried on. The water-deposited soils among the teelas may therefore be more

coarsely sandy than the teelas (because clay was carried on). Soil E is an example of such a soil.

Soil F., on the other hand, is an example of the kind of soil formed from water previously slowed down sufficiently to drop its coarse sand, and then held up so that the remaining particles had to fall together.

Soil G would have been slowly deposited from stagnant water, out of which the coarser particles had deposited first. Such a soil in South Sylhet would nearly always be rich in organic matter because of the growth of peat in the pool from which only such a soil could be deposited. Since such soils are deposited only from still water, they will only be found on flat land.

The clay present in the teela land must be assumed to have been formed by the decomposition of the sandstone minerals by weathering.

Luskerpore District.

On both sides of the Luskerpore Valley the soils are mainly the weathered sandstone itself with areas of soil transported mainly from the near teelas. Peaty flats of any extent are rare, but there are deposits of bheel soil which is used for top-dressing.

On the planted areas the following soil types occur :—

Teliapara ...	... 1, 2, 4, 4, 3, type (4 examples).
	1, 2, 5, 3, 4, „ (6 „).
Surma ...	... 1, 2, 5, 4, 3, type (2 examples).
	1, 2, 3, 5, 4, „ (2 „).
Satchuri ...	... 1, 2, 5, 4, 3, type.
	1, 2, 5, 3, 4, „
	2, 5, 4, 3, 1, „
	2, 5, 4, 1, 3, „
Amo ...	... 1, 2, 5, 4, 3, type (4 examples).
	1, 2, 5, 3, 4, „
	2, 1, 4, 5, 3, „
	4, 5, 1, 3, 2, „

Chandpur ...	...	1, 2, 5, 4, 3, type (4 examples).
		1, 2, 5, 3, 4, „ (5 „).
		1, 2, 3, 5, 4, „
Chandpur—Joalbhanga	...	1, 2, 5, 4, 3, type (2 examples).
		1, 2, 3, 5, 4, „ (4 „).
		1, 2, 4, 5, 3, „
		1, 5, 2, 3, 4, „
		1, 3, 2, 5, 4, „
Chandpur—Begumkhan	...	1, 2, 5, 4, 3, type (3 examples).
		1, 2, 3, 5, 4, „ (2 „).
		2, 5, 4, 1, 3, „
Daragaon ...	...	2, 1, 5, 4, 3, type
		2, 1, 5, 3, 4, „
		2, 5, 1, 3, 4, „
		2, 3, 5, 4, 1, „
Rasidpur ...	...	1, 2, 5, 4, 3, type (2 examples).

The common occurrence of the 1, 2, 5, 4, 3 ; 1, 2, 5, 3, 4; 1, 2, 3, 5, 4 types is notable and these three may be considered the most characteristic types of the red sandy teelas soils. In these coarse sand averages about 40%, fine sand about 30%, with clay varying from 10% to 15%, but occasionally up to 20, and at a depth of one foot up to 25%, in which last case clay may exceed fine sand giving soils of the 1, 5, 2 types.

The 2, 1, 5 types from Daragaon teelas are very similar, the total sand is still up to 70%, but rather more than half of that is fine sand.

Balisera District.

Samples have been analysed from very few gardens in the Balisera district. The soils on the whole resemble those of the Luskerpore Valley, but there are larger areas of flat and plateau soils among which are found lighter soils with less clay than the teelas and also more evenly graded, and therefore stiffer soils than the teelas. In this district also there are no large areas of peaty soil.

The following soil types are examples of the real teela soil :—

Mirzapore ...	... 1, 2, 5, 4, 3.
	2, 1, 5, 4, 3.
Sathgaon ...	... 1, 2, 5, 3, 4, (10 examples).
Baraoora ...	... 1, 2, 3, 5, 4.
Chatali ...	... 1, 2, 4, 3, 5.

Examples of more evenly graded stiffer soils from the flats are :—

Mirzapore ...	... 2, 5, 3, 4, 1,
Bararoora ...	... 2, 3, 5, 1, 4,
Mazdehee ...	... 2, 4, 5, 1, 3,

Coarsely sandy deposit :—

Baraoora ...	... 2, 1, 3, 4, 5.

Doloi Valley.

The Doloi Valley also is mainly a district of teela and plateau tea with no large areas of bheel planted. Soils similar to those of the western valleys are found ; but on the whole, fine sand rather than coarse sand predominates, while clay is generally somewhat higher than in Luskerpore and Balisera.

The following soil types are found :—

Madabpore ...	... 1, 2, 5, 4, 3.
	1, 2, 3, 5, 4.
	1, 5, 2, 4, 3.
	2, 1, 5, 4, 3.
	2, 1, 5, 3, 4.
	2, 1, 3, 5, 4.
	2, 1, 3, 4, 5.
	and
	5, 4, 3, 2, 1 with high organic matter.

The last is a clay-bheel, the remainder being normal teela and plateau soils.

Patrakola ...	...	1, 2, 5, 4, 3.
		1, 2, 5, 3, 4.
		1, 5, 2, 4, 3.
		1, 2, 3, 5, 4.
		2, 1, 5, 3, 4.
		2, 1, 3, 5, 4.
		5, 2, 3, 4, 1.
		2, 3, 5, 4, 1.

The last two are water-borne, more-recently-deposited soils, while the first six are normal teela and plateau soils.

Doloi ...	...	2, 1, 3, 5, 4.
		2, 3, 1, 5, 4.

The later is an unusual type, but clearly closely related to the former, which is a common type of teela soil.

Champarai ...	...	1, 2, 5, 3, 4.
		2, 1, 5, 3, 4.
		2, 5, 3, 4, 1.
		2, 3, 5, 4, 1.
		2, 4, 3, 5, 1.

The last three bear no relation to teela types of soil, and must have been laid down more recently by water moving too slowly to carry coarse sand.

Kurmah ...	...	1, 2, 5, 3, 4.
		2, 1, 5, 3, 4.
		2, 1, 5, 4, 3.
		2, 1, 3, 5, 4.
		2, 3, 1, 5, 4.

The first four above are common types of teela soil, the fourth was noticed also at Doloi.

New alluvial soils also occur as at Champarai.

	2, 5, 4, 3, 1.
	2, 5, 3, 4, 1.
	2, 3, 5, 4. 1.

It will be noticed that these are the types of soil which would be obtained if nearly all the coarse sand were removed from the common teela types :—

1, 2, 5, 4, 3.
1, 2, 5, 3, 4.
1, 2, 3, 5, 4.

Water washing over teelas and carrying away soil would drop the coarse sand when the water lost speed and deposit the whole of the remaining particles when the stream was held up at lower levels. In this district, however, such soils are commonly of very low acidity, and show more phosphoric acid, and lime or magnesia than the normal teela soil. It would appear therefore that the water which deposited these soils was flood water which had run over rocks containing more limestone than the normal teela soils.

Lungla District.

The Lungla district consists mainly of the spur which is an extension of the Langterai Range. This spur is broken between Kannyhatti and Langla by the valley of the Manu River, and through this break the Assam-Bengal Railway also runs. The island of red soil thus cut off from the northern end of the spur consists mainly of low teelas and plateaux very suitable for tea. Here some of the earliest gardens were opened out, and the area is now almost completely occupied by tea gardens. Of the main spur, the northern tip only is occupied by tea, the remainder being high teelas. Soils of the common teela types occur in both parts of the district, but less common types occur (more particularly on the "island") having the appearance of normal teela soils but with unusually low coarse sand. These have apparently been water-sorted. In this district also, top dressing with bheel soil has been so common and applied to so great an extent that the composition of the surface soil has been changed, and this shows particularly in the organic matter content, which is generally above the average for teela soils. No considerable area of planted

bheel soil, however, exists in this district. The following types of soil occur :—

Morapur ...	... 1, 3, 2, 5, 4.
	2, 3, 4, 5, 1.
	2, 3, 4, 1, 5.
Karimpur ...	... 1, 2, 3, 5, 4, (2 examples).
	1, 2, 5, 3, 4.
Etah ...	... 1, 2, 5, 4, 3, (4 examples).
Rajnugger ...	... 1, 2, 4, 3, 5.
	1, 2, 5, 4, 3.
	3, 2, 4, 5, 1.
	2, 3, 4, 5, 1.
	2, 5, 4, 3, 1.
	3, 4, 5, 2, 1.
	5, 4, 3, 2, 1.
Langla ...	... 1, 2, 5, 3, 4.
	1, 5, 2, 3, 4.
	2, 1, 5, 3, 4.
	2, 3, 1, 5, 4.
	3, 2, 1, 5, 4.
	3, 2, 1, 5, 4.
	3, 2, 5, 1, 4.
	2, 3, 5, 4, 1.
	5, 3, 2, 1, 4.
Hingajea ...	... 2, 1, 3, 5, 4. (3 examples).
	2, 3, 1, 5, 4.
Burramsal ...	... 1, 2, 5, 4, 3.
	1, 2, 3, 5, 4.
	2, 1, 3, 4, 5.
	5, 4, 1, 2, 3.
Allynugger ...	... 1, 2, 5, 3, 4.
	2, 1, 5, 3, 4.
	2, 1, 3, 5, 4. (3 examples).
	2, 5, 1, 3, 4.

Shamshernugger ...	1, 5, 2, 3, 4
	1, 2, 5, 3, 4, (3 examples).
	1, 2, 3, 5, 4, (2 „).
	2, 1, 3, 5, 4.
	2, 3, 1, 4, 5, (2 examples).
	3, 2, 1, 4, 5.
	2, 5, 4, 3, 1.
Kannyhatti	1, 2, 5, 3, 4, (2 examples).
	1, 2, 3, 5, 4, (2 „).
	2, 1, 3, 5, 4.
	2, 3, 1, 5, 4.
	2, 3, 5, 1, 4.
Chatlapore	1, 2, 5, 3, 4, (2 examples).
	1, 2, 5, 4, 3, (5 „).
	2, 1, 5, 3, 4, (2 „).
	2, 1, 3, 5, 4, (2 „).
	2, 1, 3, 4, 5.
	2, 5, 1, 3, 4.
	5, 2, 1, 3, 4.

Juri District.

In the Juri District comparatively large areas of flat land occur, among the teelas and undulating land of red soil. Very few analyses of the soils of the district are, unfortunately, available.

At the northern end of the valley the red soils appear to be generally heavier than the normal red teela soil of South Sylhet.

At Sonarupa teela soils of the less common 1, 2, 4, 5, 3 and 2, 1, 4, 5, 3 types occur. These, however, are close relations of the normal types 1, 2, 3, 5, 4 of 2, 1, 3, 5, 4.

From Kapnapahar we have three examples of the type 2, 3, 1, 5, 4 which was found also on several gardens of the Langla district. At the northern end of the valley the teelas appear to be of the normal sandy teela types, an example of common 1, 2, 5, 4, 3 being recorded from Phooltollah.

Examples of the heavy flats of the district are :—

From Sonarupa	...	... 4, 2, 5, 3, 1.
		4, 5, 2, 3, 1.
		4, 5, 2, 3, 1.
and from Kapnapahar		... 3, 2, 4, 5, 1.

The flats generally are now rather poor clays, or loams ; but peaty bheel soils also occur over small areas, of which no analyses are available.

Longai District.

In Longai exist large areas of flat land, formed by draining bheels. In Longai the flats have been much more important than teela land, but latterly as the bheels deteriorated the teelas assumed more importance, and by liberal top dressing with bheel soil have often been stimulated to yield very highly. The teelas appear to be generally of the normal sandy types of South Sylhet, but unfortunately only two analyses are available, both from Hattikhira.

Here occur the normal 1, 2, 5, 4, 3 type and an example of the unusually sandy 1, 2, 4, 3, 5 type.

The flats are of very variable composition.

Of the 18 analyses of flats which we have, five are of the very heaviest possible type of clay soil—the 5, 4, 3, 2, 1 type, while in seven others clay is present in high proportion. These are the types :—

5, 4, 1, 3, 2, (2 examples).
5, 3, 4, 1, 2.
4, 5, 2, 3, 1.
4, 2, 5, 3, 1.
4, 2, 5, 1, 3.

Clays, of course, are to be expected in such a district, since a clay must be the soil which is last deposited from still water, and thus it often forms only a thin band overlying other soils, perhaps sandier, perhaps peat.

Bands of such clay must lie at some depth below peat soils, to form the impervious bottom on which the bheel water lay.

As they occur as surface soils their properties are determined almost entirely by their present content of organic matter.

In the clays of which we have analyses the total combustible matter (loss on ignition) varies from 6 to 20%. Those of low organic matter content are infertile, intractable, poor soils ; those with high organic matter content have much the some properties as a pure peat soil, the influence of the organic matter being so great as to make that of the other constituents of small importance. Peat soils with organic matter exceeding 50% are found.

Patches of soil of intermediate organic matter (about 12%) occur in places (as in part of Champabari and probably the greater part of Isabheel,) where the very rich clay soil is deep and forms almost an ideal soil for tea, since the high organic matter content makes it sufficiently pervious.

It is probable that most such flats when first planted were rich at least on the surface and that the present poor clay flats are soils where the surface richness was shallow only, and has disappeared under cultivation.

Medium heavy soils also occur and approximate to the clays in their properties, becoming intractable when the organic matter is low. In one case, where a soil was described as a heavy clay, it was found to contain 54% sand and only 11% clay, but its organic matter is only 3½%. As this had undoubtedly been, in the past, very rich, this 3½% consists only of old inactive residues, and it undoubtedly is now a hard, intractable soil although of the 2, 3, 4, 5, 1 type, which is one on which tea usually does well.

Other medium types found in the district are :—

3, 2, 4, 5, 1, (3 examples).
2, 5, 4, 3, 1.
2, 4, 1, 3, 5.

Light soils also occur such as the 1, 2, 4, 5, 3 ; 2, 1, 4, 5, 3. These are usually in this district well mixed with peat and do excellently at first, but deterioration is generally rapid, and recovery very difficult indeed.

Chargola District.

The tea land of the Chargola district consists of large areas of flat land spread along both banks of the river, and of the low teelas bordering the valley, and appearing among the flats.

In this district the flats are probably of major importance.

Unfortunately, we possess no analyses of gardens of the right (East) bank of the river, but soils on both banks appear to be similar.

The soil of the red teela and undulating land of this part, the farthest east, is generally almost exactly the same as is found in the far west and throughout South Sylhet.

Of the 22 analyses of teelas which we have, ten are of the commonest 1, 2, 5, 4, 3 type, two are of the almost exactly similar 1, 2, 5, 3, 4, while the types, 2, 1, 5, 4, 3 ; 2, 1, 5, 3, 4 ; 2, 1, 4, 5, 3 ; 2, 1, 3, 5, 4 which are frequently found on teelas also occur. Single examples of the 5, 1, 4, 2, 3 ; 2, 5, 3, 1, 4 ; 2, 3, 5, 4, 1 which are uncommon are also found.

Teelas here as throughout South Sylhet are usually deficient in phosphoric acid and potash. Organic matter is often fairly high, which is accounted for by the large amount of top dressing which has been done.

In cases where very high organic matter has been found it has clearly been caused by excessive top dressing. In such cases the tea has nearly always done well at first and then deteriorated, having been sooner or later seriously attacked by many diseases. This effect must be ascribed to over-stimulation of the bushes by excessive and unbalanced manuring.

Among the flats very few cases of real peaty bheel now occur. They are generally medium loams to heavy clays in which, where the tea is good, organic matter is still high. Where organic matter is low, the soil has deteriorated to medium or even to very poor tea land.

Examples of flat soils are—

Maguracherra ...	... 5, 4, 3, 1, 2.
	5, 4, 3, 2, 1.
	4, 5, 3, 2, 1.
	3, 5, 4, 2, 1.
	3, 4, 5, 2, 1.
	2, 3, 5, 4, 1.
Balicherra ...	... 5, 4, 2, 3, 1.
	2, 5, 4, 3, 1.
	4, 2, 5, 3, 1.
	2, 5, 3, 4, 1.
Chargola ...	... 5, 4, 3, 2, 1.
	4, 5, 3, 2, 1.
	4, 2, 5, 3, 1.

Flat land which is in appearance the same as teela land and really represents either a low-lying outcrop of teela soil, or drift from teelas also occurs.

In analysis such soils resemble teela soils. Examples are :—

Balicherra ...	... 1, 2, 5, 4, 3.
	1, 2, 5, 4, 3.
Kalacherra ...	... 1, 2, 5, 4, 3.
	1, 2, 4, 3, 5.

A few patches of very sandy soil occur on the flats as at :—

Kalacherra ...	... 1, 2, 3, 4, 5.

CHARACTERISTIC TEELA SOILS OF SOUTH SYLHET.

The notes on each valley have indicated that similar soils are found in every valley. Below are shown analyses of characteristic teela soils.

	From Teliapara.		From Allynuggur.		From Sathgaon.		Heavy soil from Lungla
	Surface. 1	Subsoil. 2	Surface. 3	Subsoil. 4	Old tea 5	New tea 6	7
MECHANICAL ANALYSES.							
Coarse sand	36·4	35·4	25·1	19·4	49·9	30·5	20·2
Fine sand	22·3	22·0	34·9	31·8	23·1	24·1	25·6
Silt	11·4	7·7	12·8	14·8	8·2	14·6	19·9
Fine Silt	12·2	11·7	10·9	10·8	6·5	7·2	7·2
Clay	13·6	20·0	11·1	17·7	10·2	16·4	20·0
Loss on ignition (total organic matter)	3·65	3·19	4·85	4·44	2·50	6·1	6·9
Soil type	1, 2, 5, 4, 3	1, 2, 5, 4, 3	2, 1, 3, 5, 4	2, 1, 5, 3, 4	1, 2, 5, 3, 4	1, 2, 5, 3, 4	2, 1, 5, 3, 4
CHEMICAL ANALYSES.							
Grandeau organic matter (soluble humus)	1·85	1·36	1·84	2·59	1·02	1·90	2·95
Insoluble silicious matter	87·9	87·0	87·8	85·3	92·4	86·1	83·1
Acidity	1479	912	1778	2003	694	1516	2256
Total Nitrogen	·090	·099	·082	.057	·064	·147	·116
Available phosphoric acid	·006	·002	·005	.002	·006	·007	·006
„ potash	·006	·009	·010	.009	·004	·008	·002
„ lime	·026	·017	·031	.014	·024	·021	·024
„ magnesia	·016	·012	·012	.012	·009	·007	·012
Total phosphoric acid	.070	·075	·047	.074	·023	·015.	·067
„ potash	·209	·265	·223	·290	...	...	...
„ lime	·073	·103	·094	·104	...	...	...
„ magnesia	·176	·215	·220	·245	...	...	...

SURFACE SOILS.

No. 1 is a fair example of an average red sandy teela soil of the common 1, 2, 5, 4, 3 type.

Compared to soils with so much sand found in other tea districts it is fairly well provided with nitrogen and even the organic matter is not deficient; but it is distinctly low in available potash and phosphoric acid. In these respects it is typical of South Sylhet soils, while in acidity and total potash, lime and magnesia it is also about normal. In total phosphoric acid it is distinctly above the average, which is usually about ·04% while much lower figures as in Nos. 5 and 6 are sometimes found.

No. 3 is an example of the more evenly graded and less coarsely sandy 2, 1, 3, 5, 4 type of soil. Chemically it is of about average composition, except that its available potash is higher than is common.

No. 5 is an example of the common teela type 1, 2, 5, 3, 4, and represents the usual very sandy red teela soil. Very few teela soils are more sandy than this, yet even here the clay fraction (after ignition) is over 10%, whereas in the real sands of the new alluvium clay is generally much lower, even below 1%

This analysis is recorded to show in what figures deterioration from long cultivation shows. The low figures representing organic matter (loss of ignition and "soluble humus") are particularly noticeable, and so also is the low percentage of nitrogen. Phosphoric acid and potash, however, do not show by analysis any very great change because these are usually low even in a virgin soil. The low figure for acidity is relatively common in teela soils long under cultivation and is probably to be associated with the diminished organic matter content.

No. 5 now carries every poor tea.

No. 6 is a newly cleared area bearing very fine tea, and although a rather heavier soil its figures may conveniently be compared with those of No. 5.

No. 7 is an example of the heavy soil which is rarely found as a surface soil on South Sylhet teelas. Where found they appear sometimes to represent a heavy subsoil exposed by the removal of the lighter surface soil by wash, but in this case very heavy top-dressing with clay-bheel soil may be strongly suspected to have considerably affected the texture of the surface soil.

The next two Nos. 8 and 9 analyses illustrate the changes in the soil which follow very heavy top-dressing with peat-bheel soil.

	No. 8.	No. 9.
Coarse sand	31·0	25·3
Fine sand...	25·6	21·3
Silt	19·2	11·1
Fine silt	5·2	16·2
Clay	12·3	18·2
Loss on ignition	6·34	7·86
Soil type	1, 2, 3, 5, 4	1, 2, 5, 4, 3
Grandeau organic matter	3·04	4·67
Insoluble silicious matter	87·3	81·4
Acidity	3477	3328
Total Nitrogen	·083	·218
Available phospheric acid	·019	·032
„ potash	·001	·007
„ lime	·012	·030
„ magnesia	·014	·006
Total phospheric acid	·085	·063

The very high "loss on ignition" and "Grandeau organic matter" are particularly noticeable as would be expected from the addition of large quantities of peaty material.

The available phosphoric acid is also very greatly raised. This is not altogether due to the actual addition of phosphoric acid, but probably in greater measure to the greater solubility of the phosphoric acid on account of the greater acidity of the soil.

In No. 9 the nitrogen is very high. On this soil the tea still yields well, but the effect of over-stimulation shows in greatly increased attack by blight, particularly stem diseases during hot, droughty seasons.

On No. 8, the tea is literally dying out. Although the nitrogen content is still high for a teela soil, the nitrogen is present chiefly

as old peat residues not available to the plant, so that the tea now suffers from partial starvation following previous over-stimulation.

Many such cases of serious deterioration following excessive top-dressing with bheel occur throughout South Sylhet. Their treatment offers a difficult problem.

The analysis of the soil would suggest gradual correction of the abnormal acidity by liming; and also addition of potash, original deficiency of the soil in this constituent having been rendered more serious by the presence of nitrogen in such abundance. In cases like No. 8 readily available nitrogen would also have to be supplied pending the return of healthy conditions.

Subsoils.

Nos. 1 and 2 represent the surface and subsoil of a teela soil. Both this pair and also Nos. 3 and 4 illustrate the common feature of red teela soils that the subsoil is heavier than the top soil. This feature is of some importance since it accounts for the fact that roots of tea and shade trees do not always penetrate as deeply as would be expected on naturally well-drained teelas. Frequently subsoils are rendered more permeable by the presence of small red nodules of stony hardness (locally called "Kankar"). These nodules are therefore useful when not in excess. There are many cases, however, when the subsoil at shallow depths (and even the surface) of teelas consists of practically nothing but a collection of nodules of about $\frac{1}{2}''$ diameter. These are made good use of in dressing roads, but naturally do not by themselves constitute a good tea soil.

The nodules consist of particles of the sandy soil cemented together by oxides of iron and aluminium. They represent the "hard pan" which would have been formed had this cement formed over a continuous layer, instead of in nodules. One or two instances of practically continuous layers have been noticed. In one case such a layer at about 1 foot from the surface of a teela accounted for the failure of a clearance after one to two years' growth.

The subsoils are not generally so much poorer than the surface soils as they are on younger soils.

Treatment of Teela Soils.

It has now been shown that the teela soils of the whole district may be looked upon as essentially the same, with minor variations.

Their chief characteristic is their extremely light physical texture. They contain about 70% sand, but since they commonly contain about 15% clay, their physical condition is much more friable than would be expected.

It is observed, however, that red soils wherever found in the tea districts are much lighter than would be expected from their mechanical analyses. The "clay" figure in mechanical analysis only gives the percentage of particles below ·002 mm. (one 12500th of an inch) in diameter, and in red soils a relatively small percentage of these are in a colloidal or sticky state. For example the red soils of the Dooars often contain such high percentages of clay, that if they were yellow soils they would act as very heavy soils which in wet weather would be impervious, sticky clays impossible to work, whereas they are in reality nice friable loams. So instead of being light loams these South Sylhet teelas behave like coarse sands, and suffer the disadvantages of such soils. These disadvantages appear mainly during droughty seasons, for tea flourishes in sand so long as the water content is not too low.

For this reason the teela soils benefit most from treatment directed towards improvement of their physical condition so that they may better withstand drought. Such improvement comes mainly from the addition of material which will "bind" the soil. Such materials are cattle manure, green manure, and fresh bheel soil.

Bheel soil, however good while fresh, loses in time its sticky colloidal particles, and renders the soil more open than before and hence excess of it eventually may make worse the physical condition of the soil to which it is applied. It appears to have been forgotten also that bheel soil is generally about as rich in nitrogen as cattle manure containing often about ½% nitrogen. 5 tons of such material would provide about 56 lbs. nitrogen per acre—a good dressing for one dose. Five tons per acre amounts to about one

basketful to every four bushes, but bheel soil has usually been applied to cover the soil completely and sometimes to as much as a foot thick. Such dressings amount to many hundreds of tons per acre and provide an enormous quantity of nitrogen.

The acidity of the soil is also very greatly increased, probably beyond what is desirable even for tea.

There is at present no direct evidence on this point but it appears probable that bheel soil should be used in quantities not exceeding 10 tons per acre at a time and that it should be accompanied by light liming. Since bheel soil supplies no potash, bheel soiling should also be balanced by addition of potash manure.

Green manures should be grown on as great a scale as labour allows, and in this district of deficient phosphoric acid, should always be accompanied by phosphatic manure.

Cattle Manure is of the very highest value, and is already used very considerably, but it is worth special effort to increase the area treated with it. It will give best results used at the rate of about 5 tons per acre.

Good rotations of manuring would be as below :—

A.—Where bheel soil is available.

1. Bheel soil ... ... 5 tons
   Muriate of potash ... 60 lbs.
2. Crushed limestone ... ½ ton.
3. Mineral phosphate ... 2 cwt.
   Green crop.

B.—On normal teela soils where no bheel soil is available.

1. Cattle manure 5 tons per acre, if available or complete mixture as in (5).
2. *Nil.*
3. 3 cwt. mineral phosphate.
   Green crop.

4. Mixture to supply 30 lbs. nitrogen and 30 lbs. potash *e.g.* at present prices.

   7½ mds. oilcake or 2 mds. sulphate of ammonia and 60 lbs. muriate of potash.

5. Complete mixture if possible mainly of organic nature.

   e.g. 300 lbs. fish manure.
   50 „ sulphate of ammonia.
   40 „ muriate of potash.

C.—Trenching.

Since the subsoil is so generally heavier than the surface soil, occasional trenching or pitting will naturally be of great value, and should be used as far as labour will allow. To be of much value the trenches or pits must be filled with some form of organic matter for which purpose cut green jungle is not always available. In such cases high green crops must be grown to provide the necessary green stuff. The shade will also be useful except where being over heavy, it appears to increase mosquito blight.

A rotation to bring this in would be as below :—

Where lime is thought necessary it should follow the trenching since it will reduce tendency to spread of root-diseases along trenches.

1. Boga medeloa planted in hedges along contours as far as possible.

   Complete manure forked in around bushes.

2. Boga medeloa left up and lopped up the sides as necessary. Green parts to be trenched or pitted at end of season. Heavy wood should be left on surface for coolies to remove.

3. Lime, if any, according to soil, and manurial mixture if cost allows.

4. Mineral phosphate, and cowpeas or dhaincha to be hoed in when ready.

5. Manurial mixture.

D.—For areas suffering from previous over-manuring with bheel soil.

(Experimental only).

1. Crushed limestone ½ to 2 tons according to soil broadcasted whenever labour is available.

Nitrate of soda 200 lbs.
Muriate of potash 60 „ } forked in round bushes.

2. Cattle manure 5 tons per acre.

FLAT SOILS OF SOUTH SYLHET

Bheel Soils

Peats.—The question of the deterioration of the real peats is hardly one to be dealt with here. It affects Cachar probably even more than Sylhet.

Little fresh information also is to hand and little can now be added to the notes given in Quarterly Journal 1922, Part IV, p. 152.

Top dressing with fresh peat is the only treatment found of any really great value as manure; but the importance of not allowing these soils to dry has become clearer. The results of experiments on keeping up the water level in the dry season have been excellent.

Peaty sands.—This case approximates to that of the true peats and was also dealt with in Quarterly Journal, 1922, p 152.

Heavy and Medium Soils.—Here the problem now appears comparatively simple. The peaty material which originally made these soils so fertile disappears under the influence of cultivation and drainage.

Where it has already disappeared it must be added again, and the best method of doing so, whenever practicable, is to add fresh peat. Green manure and cattle manure are also of enormous value, while crops may be maintained by the use of readily available manures. As is usual on heavy soils phosphates are of great value;

while wherever acidity is high, light liming should be useful in maintaining the soil's permeability.

The recovery of bheels which have reverted to heavy soils is therefore only a matter of work and expenditure.

The problem of the prevention of deterioration is however one which should receive more attention.

A garden in the Longai district illustrates one big factor in deterioration. Here there is a flat of rich clay which for years averaged over 20 mds. per acre. It was never cultivated simply because the bushes were so big and widespread as to make it impossible. No jungle at all grew under the heavy shade, but the soil remained in beautiful condition. The tea, however, was too high and could only be plucked by men.

Part of it was therefore collar pruned. On this part jungle then grew vigorously, and good cultivation was put in. After a few years it became very noticeable that a good section had become a very bad one. This was partly because diseases attacked the cut stems, but even the healthy bushes were clearly going off.

The cut down area was separated from the still high and heavy yielding tea only by a narrow drain. Samples of the soil were taken from each side of this drain a few bushes away from it.

Both samples were found to be very similar heavy clays, but in the sample from the uncultivated area the organic matter was 11·48%, while in the cultivated soil only 9·0% organic matter remained.

This disappearance of organic matter is a matter known to all. Many soils which are now clay flats are well known to have been peat-bheels when first opened out. The above example shows the rapidity of the disappearance, and points the moral. On such soils cultivation is dangerous. Jungle must be kept down in the early stages, but as soon as (by the help of shade trees and broad-spreading tea bushes) jungle is kept down, the best treatment for such soils is to leave them alone rather than attempt to raise a little more crop by wasteful expenditure of the organic matter through cultivation. In young or cut-down tea cultivation will

be necessary to keep down jungle, but the cultivation should aim at keeping down jungle with as little disturbance of the soil as possible.

The deteriorated heavy soils are very common particularly in the Longai and Chargola Districts. The three analyses below illustrate the variation in heavy soil found.

	A. Peat clay very fertile.	B. Intermediate soil Tea still good.	C. Bad soil replanted tea hardly keeps alive.
MECHANICAL ANALYSES.			
Coarse sand	5·4	5·1	1·9
Fine sand	5·1	12·4	11·8
Silt	8·4	14·8	33·5
Fine silt	35·7	26·8	19·6
Clay	30·6	32·9	27·1
Loss on ignition	14·4	7·54	5·70
CHEMICAL ANALYSES.			
Grandeau organic matter	4·29	2·08	0·99
Insoluble silicious matter	69·6	77·4	77·6
Acidity	5880	2906	1537
Total Nitrogen	0·370	·149	·139
Available phosphoric acid	·035	·027	·026
„ potash	·015	·009	·014
„ lime	·030	·076	·137
„ magnesia	·020	·042	·054
Total phosphoric acid	·010	·082	·089
„ potash	·52	.....	.....
„ lime	·12	.....	.....
„ magnesia	·48	.....	.....

Soil A contains so much organic matter that it is still a rich peaty soil. It is this type of soil which should receive the minimum of cultivation necessary to keep down jungle.

Soil B was undoubtedly once similar to soil A. On it the tea is still good but without the rank exuberance of growth seen on Soil A. It has reached a stage where organic matter should be added.

Soil C is now merely a sticky intractable clay, which only a dressing of fresh peat can renovate in a short time. It still retains high nitrogen, but this is clearly in an unavailable state. Its acidity has been reduced by liming and this no doubt has rendered the soil more permeable than it was, but more than lime is required.

The young tea planted three years ago is in miserable condition.

As there is now no peat near it, the only chance is to add other forms of organic matter, and to add readily available nitrogen to keep the tea growing pending the recovery of the soil. Since fairly heavy liming has already been done, no more would be advisable for some time in this case.

A good treatment would be :—

1. 20 tons cattle manure per acre broadcasted.

   Boga medeloa sown in hedges in alternate rows to provide shade, and from occasional lopping up the sides, additional organic matter.

2. 2 mds. sulphate of ammonia forked in around bushes.

   Boga medeloa trenched in at end of season across direction of drains.

3. 3 cwt. mineral phosphate per acre broadcasted. Cowpeas sown in every line and hoed in when ready.

   2 mds. sulphate of ammonia per acre forked in around bushes.

If no cattle manure were available one would have to rely on green crops, and, wherever available near at hand, green jungle cut and carried on to the land.

Such treatment may seem expensive, but the soil is in a very bad state and nothing less would be of much value. Perhaps, in fact, it is too bad in this particular case to be worth treatment. The scheme, however, shows the kind of treatment required by these deteriorating clays which occupy very large areas in Sylhet.

Such areas must always be very well drained.

Flat Soils other than Bheel Soils

These generally resemble teela soils and respond to similar treatment.

METEOROLOGICAL OBSERVATIONS IN ASSAM, 1923

BY

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INTRODUCTION.

The predominating factor which has made Assam such a successful tea growing country is its climate. The tea bush grows on practically any type of soil from the peats or bheels of the Surma Valley and the heavy clays of the Dooars to the light, poor sands found near the Brahmaputra. In order that the tea bush shall thrive it must have a warm, moist climate with no long droughts. This first necessity was recognised many years ago and the following extract, taken from the Tea Cyclopaedia published in 1881, is of interest in this connection.

"Tea, it may be promised, will grow almost anywhere, but not very many climates will enable it to pay.

To describe the best climate in two words, we point confidently to Eastern Bengal; indeed, the judgment of a considerable portion of the Indian public interested in tea has long since pronounced the same decision. A hot, moist climate, where the thermometer in the shade never exceeds 95°, never falls below 55°; where the rainfall yearly aggregates 100 to 130 inches; where there is never any long drought, but where rain falls at reasonable intervals all the year round; where heavy dews are frequent; where morning fogs are not uncommon; where the sun shines hot in an atmosphere perfectly free from dust; where at no season can a breath of hot wind be felt; where light, penetrating rain is more common than furious downpours; where the effect of the entire climate is essentially enervating to man, and takes much out of him;—these are the conditions that constitute, in our opinion, good climate for tea, and where it is wise, if wise anywhere, to make tea gardens. Fever and tea go together.

It may be a painful fact for tea planters, but it is no less true. No highly successful tea district can ever be a healthy one."

Eastern Bengal probably refers to Cachar for the temperatures recorded in the Assam Valley fall considerably below 55°. The statement that fever and tea go together fortunately no longer holds good.

The China tea bush, which is in some respects hardier than the Assam and Burma varieties, can withstand frost and will tolerate a climate resembling that of Southern England, but, like the other species, in order that it shall yield leaf readily under the unnatural conditions of pruning and plucking to which it is subjected it must have a warm, forcing climate.

During the past few years the climate has been systematically studied at Tocklai, and as observations accumulate it becomes more and more easy to define the relationship between the weather and the crop and condition of manufacture. By thus tracing to its source the influence of the weather it becomes simpler to estimate the influence of pests and blights on crop outturn or the effect of a change in plucking or manufacture on a particular season's tea.

The aim and plan of the present paper is similiar to that of the preceding articles on meteorology. New observations are recorded and an attempt is made to correlate them with the growth of the tea bush and the manufacture of tea.

The Monsoon in Assam during 1923.

The year 1923 was the wettest recorded at Tocklai, in spite of the rain shortage during the early months. From April to September the rain was continuous and heavy. The rainfall is denoted on the Chart by means of vertical black lines.

After a dry January there was good rainfall early in February which was accompained by a rise in temperature such as is invariably experienced during rainy periods before the monsoon breaks. This rise is best shown by the minimum temperatures, for the maxima often give a false idea of the true state of affairs. Thus the average maximum temperature for the week ending February

4th was 72°F, a drop of 5°F below the value the previous week, although the minimum showed an increase of 2°F over the minimum of the previous week. The rise in temperature is due to the inflow of warm, moist air from the South following on a relaxation of the steady pressure from the North. When this change is accompanied by cloudiness the maxima are lowered.

March was a dry month and it was during this period of drought and rapidly rising temperatures that the poor start of the season was definitely decided.

In April, rain was plentiful and from that period the *Chota barsat* merged imperceptibly into the monsoon proper. Both April and May were wet, cool months which retarded the start of the season. The week ending June 17th was typical of the break of the monsoon and the sky was covered with masses of low clouds, driving quickly into the Valley. Another cloudy period was that ending September 16th. Both these periods were marked by low maximum temperatures.

After September 16th the monsoon clearly weakened and rain came spasmodically. The rainfall in October was satisfactory and the end of the season was, on the whole, good.

Below are given tables showing the monthly rainfall and the degree of wetness at Tocklai during the past five years. The degree of wetness which is obtained by multiplying the amount of rainfall by the number of wet days and dividing by the number of days in the month is a first aproximation to the distribution of rainfall.

Table showing Monthly Rainfall and Degree of Wetness at Tocklai.

Months.	Rainfall in Inches.					Degree of Wetness.				
	1919.	1920.	1921.	1922.	1923.	1919.	1920.	1921.	1922.	1923.
January ...	0·28	0·63	1·63	0·74	nil	0·02	0·04	0·42	1·58	...
February ...	0·97	2·73	0·86	0·12	2·77	0·17	0·87	0·21	0·01	0·93
March ...	0·75	6·15	4·21	3·14	0·43	0·07	2·97	1·22	0·81	0·69
April ...	7·41	9·08	14·03	7·79	10·84	1·91	3·60	10·29	3·11	7·94
May ...	6·57	6·73	9·28	6·16	11·97	2·54	2·38	5·08	3·17	7·72
June ...	22·09	9·89	7·71	11·67	20·29	12·51	6·59	6·42	10·11	13·52
July ...	16·37	14·18	14·52	12·87	18·79	10·56	8·46	9·84	10·37	16·36
August ...	10·71	9·22	9·71	19·23	17·11	4·42	5·94	6·57	16·12	13·24
September ...	9·59	6·17	14·23	7·32	14·12	5·75	3·08	9·49	3·90	9·88
October ...	9.40	2·47	5·15	2·65	3·93	3·33	0·72	2·66	0·59	1·01
November ...	0·40	0·40	nil	1·17	1·55	0·56	0·26	...	0·16	0·10
December ...	0·01	0·13	1·14	1·03	0.11	0·01	0·01	0·11	0·16	0·04
Total ...	75·08	67·55	82·47	73·89	100·91					

As observations accumulate, the irregularity of the rainfall in the early part of the year in Assam becomes more and more evident. The most critical period is from the end of January to about the middle of April, a period somewhat earlier than was formerly supposed.

During the critical months the success or otherwise of nurseries is determined. The year 1919 was the worst for many years so far as nurseries were concerned. Reference to the tables above show that to the end of March in that year, only 2.00 inches of rain had fallen, and in April, with a rapidly rising temperature, the drought continued till the middle of the month. At Tocklai some nurseries were such failures that they had to be hoed in.

The year 1920 was perfect for nurseries, for rain was plentiful and the sky was naturally shaded with clouds. Even in this year, however, much better plants were obtained from the areas which were artificially shaded.

Of the three following years, 1921 was good, whilst 1922 and 1923 were bad. Thus out of the past five years, only two have had satisfactory rainfall over the critical period of February, March and April, showing that it undoubtedly pays in most cases to shade nurseries.

The weather during the latter part of the season during the past five years has varied much. In 1919 it was excellent and heavy crops were made right up to Christmas. The end of the season 1920 was an average one, whilst the close of 1921 and 1922 were bad. The type of the season's close cannot, so far, be definitely correlated with actual rainfall, but the soil moisture and atmospheric humidity are probably controlling factors.

The total rainfall for 1923—100·08 inches—was far in excess of the average for the past six years, which is 79·18 inches. Yet the year was distinguished by few big falls. Totals, however, give little information, for tea can do well with 40 or 50 inches if it be well distributed over the year.

On April 22nd a cyclone of unusual violence was experienced in Tocklai and the vicinity. The width of the cyclone

as denoted by the situation of buildings destroyed and fallen trees, appears to have been about 200 yards only.

Temperature and Humidity.

Many industries, among which may be mentioned cotton, tea and tobacco, have as controlling factors the atmospheric humidity. With the tea industry, both the size of the crop and the manufacture of the tea leaf depend primarily on the moisture of the atmosphere. A careful study of humidity is therefore of great importance, and since humidity depends largely on the temperature these two factors will be considered together.

On the Chart, the maximum and minimum temperatures are shown by red lines and the vapour pressure or absolute humidity is shown by a blue line. The forms of the vapour pressure curves for the past three years show few points of similarity so far as detail is concerned. In the year under consideration (1923) there appear to be two distinct humidity rises, one corresponding with the first rains and the second coming with the true monsoon.

The months of April and May are interesting from the point of view of humidity for although the absolute humidity is increasing rapidly the temperature is also quickly rising and, on the balance, the relative humidity decreases.

The big rise in humidity in April is rather exceptional and follows on the sharp rise in temperature during this period. The drop in humidity at the end of this month which is accentuated by the earlier rise coincides with a week of high maximum temperatures. However, at this time of the season, the minimum temperatures are the controlling factors in humidity changes and the fall in night temperatures was sufficient to wring the air dry of its excessive moisture, and although on the average for the week ending April 15th a drop only about 1.5°F is shown over the previous week, there were several very cool nights.

During the monsoon, when the minimum temperatures are much steadier than in the early part of the season, the humidity generally follows the maximum temperatures.

In studying the effect of temperature and humidity on tea cultivation and manufacture we must first distinguish between *relative* and *absolute* humidity. In the discussion in last year's report it was suggested that since the relative humidity of the atmosphere represents a function of both temperature and humidity it is preferable for some purposes of correlation to consider these two factors separately, in which case, absolute humidity, a function independent of temperature, should be dealt with.

With the growing plant it is possible to distinguish between the effect of these two separate factors. Thus the temperature influences the *rate* of growth, so that high temperatures produce large leaves. The absolute humidity influences the *amount* of growth and forces the bush to produce a greater number of shoots. It will thus be seen that a comparatively cool (*i.e.*, about 80°F), moist atmosphere, which should produce a large number of slow growing shoots, should be preferable to a hot, moist one.

So far as withering is concerned the relative humidity is all important. Unless the atmosphere is unsaturated the leaf will not wither, and it is impossible to make good tea. Generally, a good wither is possible in Assam, but in the Dooars it is common for the atmosphere to remain saturated for long periods.

The problem of the final firing or *gaping* of tea has received some attention. Generally it may be said that the optimum moisture content for teas which are to be sent to Europe is between 5 and 6 % and it is usual to final fire teas before they are boxed in order that they shall contain this amount of moisture.

It has however been observed during the earlier part of the season, especially in April and May, that teas frequently do not need final firing and that such a process not only brings about a loss in weight of saleable tea but also destroys quality. After the Monsoon definitely breaks and moist air comes up the Valley in a steady flow, stored tea practically always requires final firing. The only true test on this point is a direct determination of the moisture content by drying a weighed quantity of tea in a steam oven and estimating the loss in weight.

Sunshine.

Sunshine is an important factor influencing the quality of tea in North East India, for it increases the percentage of tannin in the leaf. Cloudy skies make for long growth, which means more stalk in the tea. The season 1921 was remarkable for the amount of stalk and also for its deficiency in sunshine.

It is of interest to notice that in Japan sunshine has been found to be detrimental to the quality of Green Tea, because direct sunlight increases the anthocyan content of leaf, thereby making the tea bitter. Accordingly the best tea is shaded about three weeks before it is plucked

The table below shows the monthly sunshine average in hours, over the past six years recorded at Tocklai.

	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1918	7·0	6·1	4 2	5·8	5·1	3·3	3·7	3·7	5·0	6·2	6·3	6·2
1919	5·3	6·1	6·9	6·1	5·7	5·1	3·6	5·3	3·4	5·1	5·2	5·0
1920	4·6	4·0	4·4	4·6	4·3	3·9	5·2	5·1	5·6	4·9	6·1	5·0
1921	5·0	5·5	5·2	3·9	3·9	3·1	3·7	3·9	3·5	2·6	5·5	4·5
1922	5·3	7·4	4·5	6·1	6·0	4·1	4·5	3·5	4·4	6 1	5·9	6·0
1923	6·4	4·9	8·5	4·4	3·2	4·7	3·2	4·8	2·7	5·2	6·1	5 6

The drought in March, 1923, find its complement in a sunshine average of 8.5 hours which is a record for Tocklai. The months of April, May, July and September are well below the average, whilst June and August are well above it. So far as sunshine is concerned, then, it cannot be said that 1923 was on the whole a good year for quality.

The Soil Condition.

Throughout the year the soil temperature was taken at a depth of 1 foot and at 3 feet twice daily at 8 A. M. and 3 P. M. The curves showing the weekly averages for the two depths are of the same form but of different magnitude.

At 1 foot there is a difference of from 2° to 3°F between the morning and afternoon temperatures and any distinct change in the maximum temperature of the air is quickly shown in the top-soil temperature. At 3 feet this correlation whilst quite definite comes about 30 hours later, in a modified degree. The difference between the morning and afternoon temperatures at 3 feet is negligible.

The soil is coldest halfway through January when a temperature of about 63°F is registered at 1 foot and 67°F at 3 feet. From that period there is a steady rise till the beginning of September when maxima of 90°F and 89°F at 1 foot and 3 feet respectively were observed. These values correspond very closely with those given in 1922.

These soil temperatures were taken on a grassed plot. The temperature of clean weeded soil would naturally be considerably higher in the top foot and would also vary according to the colour of the soil. Thus the darker the soil the greater is the heat absorption and the higher the temperature. A dark coloured soil also cools more rapidly than a light coloured one and hence shows a lower night temperature.

The soil moisture of the top 9″ of the Tocklai Clearance was taken daily throughout the year and the average weekly figures are plotted on the top curve of the Chart. The outstanding feature is the drying out experienced in March, when conditions resembled those in March of the previous year.

The arrows denote the cultivation periods. The January hoe had as its main object a mulch, the formation of which would preserve the moisture during the critical months of February, March and April. The hoe in the middle of March should have been earlier in order to reform the mulch which had been destroyed by the February rain. The later hoes practically amounted to a turning of the surface layer in order to remove the jungle and little cultivation in the sense of soil disturbance was carried out. The November hoe would have had more response from the crop returns if it had been put in a week or ten days earlier. The December hoe was a deep one and the soil was then in perfect condition.

Cultivation at the end of the plucking season should be carried out with a view to the conservation of soil moisture during the period before the early rains, and for this purpose a study of dry land agriculture as developed in the semi-arid regions of America is helpful. In these regions, which comprise one half of the area of the United States, dry farming has been carried on successfully with as little as 10 inches of rainfall a year. The evaporation from a free water surface in some of these areas may be anything from 30 to 50 inches during the hot dry months so that to farm successfully great skill is required. The best means of preventing loss of water is by tillage which produces a mulch. A light hoe following on an early deep hoe does much in this direction, but deep hoeing in February or the keeping open of trenches for a long period all tend to dry out the soil.

The Tea Crop in 1923.

Apart from the early drought the tea season in 1923 was fairly good, although the weather was at times overwet and too cold.

As in previous reports, the crop from the Tocklai Clearance is taken for purposes of correlation with climatic conditions. The weekly leaf from this $3\frac{1}{2}$ acre block is shown by the crop curve on the Chart. Half the clearance is pruned annually and the other half biennially. In the year under consideration the annually pruned bushes were cut to 18 inches and the biennially pruned to 14 inches on 2 years wood. The whole clearance was plucked weekly at 27 inches.

In some ways the 1923 crop resembles that of 1922. There are two notable periods of vigorous flushing, one lasting over a month starting from the end of June, and the other lasting over about six weeks from the end of August.

There was an isolated crop rise at the end of May which was probably due to the fact that at this period all the new wood had reached 27 inches, the plucking height, and the earliest shoots which had reached that height five or six weeks earlier were giving their secondary shoots.

The crop depression on June 3rd was intensified, partly by the growing of cowpeas and the hoeing of them in at the end of May and partly by the cool period in the same month.

In June, weather conditions improved. The month opened with a blazing hot week which considerably improved the soil condition although the tea suffered from scorching and copper blight showed up badly in consequence. Cooler weather was again experienced from the 11th to the 19th, after which we had true tea growing weather, hot sunny days and warm thunder showers, mainly at night. A real heavy flush resulted on the 24th and good flushes continued till the middle of July.

On July 22nd there was a marked drop in crop. This is often noticed in the wake of one of the early big flushes before each branch is bearing its maximum number of shoots. In addition there had been a drop in the humidity in the previous week and a fall in temperature both of which would depress the outturn.

The temporary rise on July 29th may be taken as leaf overdue from the previous week.

The big flush of the season came towards the end of August when the influence of the hoe earlier in the month and the fact that the bushes were in full bearing made for the maximum crop. But for the fall in temperature about the middle of September, this flush would have been still bigger, probably at the expense of the October crop.

The decided fall in vapour pressure at the end of September definitely fixed the end of the season.

The two crop curves shown by red lines denote the leaf obtained from the annually and biennially pruned bushes which go to make up the total crop. The point of interest in that the form of the curve is exactly the same with both kinds of pruning. Similar observations were made in 1922 when the two forms of treatment were, cut to 16 inches and unpruned.

The Cold Weather Mists of the Assam Valley.

The weather in the Assam Valley in December and January resembles in many ways an English Autumn. The days are short and warm and the nights cold and misty. As the sun goes down in a red glow a sudden chill is felt and the blue smoke from the villages hangs in low strata which seem to collect the evening mist. Near villages and about clumps of trees the mist hangs low but over the bare rice fields it rises in a curve and settles again over village sites. Later on when interiors of villages are comparatively clear, thick banks of mist rest on the open rice fields, now much colder than protected areas. In the early morning the whole countryside is drenched with dew and it is not until nearly noon that the sun is sufficiently warm to dispel the last traces of the mist.

Many parts of the Assam Valley are also subject to Brahmaputra mists. Although the night, following on a warm day, may be quiet clear, in the early morning dense banks of mist, coming from the River, reach Jorhat, a distance of about 10 miles. Shortly after, Tocklai is enveloped and later the whole district up to the foot of the Naga Hills is lying under a blanket of fog. From the Naga Hills themselves the advance of the fog bank can be easily followed and from about 10 o'clock onwards the lower valleys start to fill with mist.

In order that local or radiation mists may form it is necessary for the ground to cool considerably so that the lower layers of the atmosphere shall become saturated with moisture. If the ground has been warmed up for several days the chances of a mist diminish even if other conditions are favourable. In addition, the air must not be so dry that the cooling which takes place on a calm, clear night shall be insufficient to bring the temperature below dew point. It has often been observed that after several very cold nights which have wrung a great amount of moisture from the air, several clear nights follow until sufficient time has elapsed for the re-absorption of more moisture by the atmosphere.

On cloudy nights local mists seldom form because the clouds so hinder radiation that the temperature of the air does not fall below the dew point.

An interesting instance connected with local mists has been observed in the Doom Dooma district. At one time a certain area was always free from mists but since fresh gardens have been opened out these same areas are now subject to dense fogs which do not clear off till well on in the morning. This is quite a serious matter involving, as it often does, the loss of two or three hours' labour. Forest land is always warmer at night and cooler in the day than open land which, with its greater temperature range, makes fog formation possible.

The Brahmaputra mists vary much within small areas. At Dibrugarh they are very thick but it is said that at Dehingmukh, about half way between Dibrugarh and Kukilamukh, they are worst. Below Kukilamukh they tend to diminish although at Singrighat, below Tezpur, there is frequently a very thick bank at night and the timings of Mail Steamers are arranged so as to avoid this *ghat* in the early hours of the morning.

The mists usually first collect on the sandy banks and river *churs* toward midnight and, on the River itself, somewhat later. The fog seldom moves far from the River in a northerly direction and mist in the Upper Mangaldai district is a matter for remark. During the cold weather there is a steady flow of air from the Himalayas to the Assam Valley and this breeze wafts the mists from the River towards the Naga Hills, leaving the North bank clear.

The explanation of mist formation on the Bramhaputra has been studied. It was at one time thought that the cold waters from the Himalayas might bring about the cooling of the night air necessary to produce a mist. Although this is not the cause, such a phenomenon may often be observed. Thus in April and May small tributaries may be seen entering the main stream, producing a faint mist just at the confluence. Such streams may have followed courses shaded by trees or overhanging cliffs so that they are much cooler than the main stream which has wandered between exposed hot banks for hundreds of miles.

It might at first be concluded that the conditions in the Brahmaputra Valley were similar to those described above but

temperature observations dispose of this idea. In December, a series of observations made at Kukilamukh showed that the temperature of the River was steady, day and night, at about 62°F, whilst the air temparature varied from 50°F at 7 a.m. to 68°F at noon and down again to 61°F at 10 p.m.

The formation of the River mists is undoubtedly due to the extreme temperature range experienced on the flood plain area along the River bank. Much of this area is bare sand which has practically a desert climate so far as temperature is concerned, other parts are merely covered with thatch and even this type of land is subject to great extremes of temperature. With branches of the River flowing round the *churs* there is plenty of chance for moisture absorption during the day and mist formation naturally follows at night.

The value of cold weather mists is a question of interest to the tea industry. The amount of dew deposited as measured by a rain gauge often amounts to 0·01 inches. A rain gauge is not a suitable instrument for measuring dew but the amount mentioned is indicative of the quantity of moisture deposited This amount is of little use to the soil and seldom makes any impression on the mulch.

The leaves of the bush collect the dew mostly on the upper surface. On the under surface of the leaves are pores, called stomata, which exude the water bringing up liquid food from the roots of the bush. Now the stomata are incapable of taking in an appreciable amount of water. Hence it is hypothetically possible for a bush in a dry soil to wilt, although the atmosphere is constantly misty.

The great benefit derived from mists is that evaporation from the soil ceases and the rate of transpiration or evaporation from the leaf is greatly reduced. Thus in December and January the loss of moisture is often reduced to a minimum for about sixteen hours of the day, an advantage greatly missed by many of the sun-baked gardens outside the areas regularly visited by mists.

SEASON 1923

JANUARY 7 14 21 28 | FEBRUARY 4 11 18 25 | MARCH 4 11 18 25 | APRIL 1 8 15 22 29 | MAY 6 13 20 27 | JUNE 3 10 17 24 | JULY 1 8 15 22 29 | AUGUST 5 12 19 26 | SEPTEMBER 2 9 16 23 30 | OCTOBER 7 14 21 28 | NOVEMBER 4 11 18 25 | DECEMBER 2 9 16 23 30

SOIL MOISTURE

SOIL MOISTURE 20% 15% 10%

DEEP HOE

CROP

CROP 500 Lbs 400" 300" 200" 100"

BUSHES CUT TO 18"

BUSHES CUT TO 14"

VAPOUR PRESSURE 1·00 INS HG. 0"

VAPOUR PRESSURE

TEMPERATURE 100°F 90° 80° 70° 60° 50° 40°

0·90" 0·80" 0·70" 0·60" 0·50" 0·40"

MAXIMUM TEMPERATURE

MINIMUM TEMPERATURE

RAINFALL 10 INS. 8" 6" 4" 2" 0"

RAINFALL

OBSERVATIONS MADE AT TOCKLAI EXPERIMENTAL STATION.

NOTES.

TEA SEED PRODUCTION OF JAVA AND SUMATRA.—*The Dutch East Indian Archipelago, Vol. IV, No. 71, p. 2222. Buitenzorg, January 10, 1922.*

In Java and Sumatra there are about 180 tea-seed nurseries belonging to some 134 owners. Together they cover an area of about 560 hectares (1,384 acres) and contain more than 630,000 seed plants. The majority are situated at a height of 1,000 to 4,000 feet; many seed-nurseries were laid out during the years 1901 to 1913. The 630,000 seed plants produced 8,600 maunds of seed in 1917, and when the nurseries have arrived at their full capacity for production this figure will have risen from 12,000 to 21,000 maunds, a figure which will probably be reached in 1923.

The import of seed from British India, which amounted to 8,200 maunds in 1912-13, fell to 339 maunds in 1919-20, and now that there is no question of extending tea estates, the demand for seed is naturally very small. Demand is sure, however, to increase with the return of more prosperous times, but the large imports of former days can no longer be expected, and Java and Sumatra will probably have a considerable over-production of tea-seed.

The Tea Experimental Station is helping planters to lay out seed nurseries on a scientific basis. Generally the plants are too close and it is advisable to plant seedlings about 6 feet apart and to thin them out later. Pruning should be judiciously done and moss and weeds removed, while digging, and manuring are generally unnecessary and often unprofitable because they promote the development of leaf-growth and delay the flower production. Seeds should not be gathered and only the fallen fruit should be collected, collection being made twice a week.

The laying-out of a seed nursery is specially to be recommended where an extension of an estate has been planned. If

the object is to put the seeds on the market, the fact that over-production is imminent must not be overlooked. If a seed-nursery becomes no longer profitable, the plants may be pruned off and used for gathering purposes. But if the nursery is situated at too great a distance, then there is no other remedy than to simply let the plants grow into a wood. The collecting of seed for pressing oil is also worthy of consideration.

The above extract appeared in the "International Review of the Science and Practice of Agriculture"—July 1922.